APPENDIX H

Factors Affecting Water Supply

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AMBIENT GROUND WATER QUALITY

Ambient ground water quality of the Lower West Coast Planning Area was assessed with the use of the Ambient Ground Water Quality Monitoring Network (AGWQMN). The AGWQMN is a statewide network of Monitor wells (and associated database) which is maintained by a cooperative agreement between the Florida Department of Environmental Regulation and the water management districts. The purpose of the AGWQMN is to typify regional ambient water quality. It is not intended to include wells which monitor zones of discharge of landfills, contamination sites, or any other anthropogenic pollution sources, nor is it intended to delineate specific saltwater intrusion impacts. The aquifer classifications used by the AGWQMN in the LWC Planning Area are the Surficial, Intermediate, and Floridan aquifer systems. For the Lower West Coast Water Supply Plan (LWCWSP), the wells were further segregated by specific aquifer (water table, lower Tamiami, Sandstone, mid-Hawthorn, lower Hawthorn) for a more detailed picture of water quality. Refer to Chapter III for a review of the hydrogeology and aquifer systems.

Information derived from the first four years of AGWQMN sampling (1984 through 1987) within the SFWMD was summarized and published in Technical Publication 89-1, "South Florida Water Management District Ambient Ground Water Quality," (Herr and Shaw, 1989). For the LWCWSP, district staff utilized all available data from the wells which were located within the LWC Planning Area, encompassing a time span from 1984 through 1990. Average data values of all sampling events for each well were obtained with the use of the GWIS database.

The following is a brief summary of the selected water quality parameters obtained from the AGWQMN data search for the LWC Planning Area. The water quality parameters reviewed are those which can affect the treatability of a potential drinking water source. These include chloride, sodium, total dissolved solids (TDS), iron, total organic carbon (TOC), total alkalinity, nitrate nitrogen, hardness, and color. Tables V-1 and V-2 in the Water Supply Issues and Constraints Section are suggested references for the potable drinking water standards which apply to several of these parameters. All units are stated in milligrams per liter (mg/L), except color (stated as color units). The water quality contour maps of the ambient water quality data alone do not depict the extent of saltwater intrusion along the coast, due to the deficiency of AGWQMN wells in the affected coastal areas. This topic is included in the saltwater intrusion discussion later in this appendix.

Tables H-1 through H-4 (beginning on page H-10) contain the ambient water quality data retrieved from the AGWQMN database for the water table, lower Tamiami, Sandstone, mid-Hawthorn and lower Hawthorn aquifers. Well construction information (casing and total depths) and well locations in Florida state planar coordinates are included. Figures H-1 through H-5 (beginning on page H-5) are location maps depicting the wells within each aquifer. Figures H-6 through H-46 (beginning on page H-17) contain the water quality contour maps for the selected water quality parameters. The contour plots were generated with "Surfer," a Golden Software product, using the Kriging algorithm method. Additional figures illustrating estimated chloride concentrations of the upper and lower portions of the Floridan Aquifer System (FAS), as indicated by the U.S. Geological Survey, are included as figures H-47and F-48 (beginning on page H-58).

Water Table Aquifer

Among the water table aquifer ambient wells only, chloride concentrations are within potable water standards, ranging from 5 to 158 mg/L. However, saltwater intrusion in coastal areas has caused contamination of the surficial aquifer in various localities. Connate water which remains in many places also contributes to locally elevated levels of chlorides and other dissolved minerals. Additional chloride data from the saltwater intrusion monitoring program and other sources is presented in the saltwater intrusion discussion and accompanying materials presented later in this appendix. In addition to saltwater intrusion, inter-aquifer cross contamination from the more saline FAS is a problem stemming from past irrigation practices, and from flowing FAS irrigation wells or oil test wells which were improperly constructed or abandoned. Chloride levels in the water table aquifer near La Belle are as high as 1,800 mg/L due to this problem (Smith and Adams, 1988). This problem is not restricted to the water table aquifer.

Sodium and total dissolved solids generally follow the same patterns as chlorides, and are highest in the areas of saltwater intrusion, flowing Floridan wells, and in areas of localized pockets of connate water. Sodium concentrations in the ambient wells are within potable drinking water standards, ranging from 2 to 110 mg/L. Total dissolved solids range from 31 to 981 mg/L, exceeding potable water standards in approximately 25 percent of the ambient wells.

Additional AGWQMN data indicates that the water is moderately hard to very hard (144 to 444 mg/L as $CaCO_3$), with the exception of some anomalously low levels in Glades County. It is relatively high in color and total organic carbon (TOC), due to the rich, organic nature of the overlying soils in much of the LWC. Iron levels vary from 0.190 to 5.815 mg/L, exceeding the potable standard in nearly all wells. Alkalinity normally ranges from approximately 130 to 385 mg/L (as HCO_3), again with the exception of some very low values in Glades County. Nitrate nitrogen concentrations are far below potable standards in all wells.

Lower Tamiami Aquifer

Due to the relatively small number of ambient wells in the lower Tamiami aquifer, the water quality analysis is roughly limited to west-central Collier County. Generally speaking, in the aquifers of the LWC Planning Area, ground water quality degrades with increasing depth, with respect to chloride, TDS, and sodium. Nevertheless, in the lower Tamiami ambient wells, unimpacted by saltwater intrusion, the ranges of chlorides (12 to 155 mg/L) and sodium (9 to 87 mg/L) remain well within potable water standards. Total dissolved solids range from 204 to 647 mg/L, often in excess of potable standards. Naturally, in areas affected by saltwater intrusion or cross contamination from deeper, more mineralized aquifers, these parameters may be present in far greater concentrations. Connate water also accounts for localized pockets of highly mineralized water. Additional information on chloride levels in areas of saltwater intrusion is the Saltwater Intrusion section of this appendix.

Ranges of other parameters in the ambient wells are as follows (all in mg/L except color): iron: 0.050 to 2.220; TOC: 6 to 54; alkalinity 174 to 340; nitrate nitrogen: 004 (detection level) to 0.009; color: 20 and 39 (only two data points); and hardness: 179 to 467 (hard to very hard).

In Collier County, lower Tamiami water quality with respect to dissolved solids appears to degrade toward the south, although TOC levels increase inland, toward the northeast.

Sandstone Aquifer

Moving deeper, within the Sandstone Aquifer, the overall averages for chloride, TDS, sodium and hardness continue to increase with depth, above the levels found in the overlying aquifer. Conversely, levels of iron, TOC, and color are lower in the Sandstone than in the overlying aquifer, while alkalinity and nitrate levels remain relatively constant. Average well data ranges are as follows (all in mg/L except color): chloride: 30 to 1010; TDS: 374 to 2139; sodium: 38 to 593; iron: 0.045 to 1.593; TOC: 1 to 44; alkalinity: 122 to 433; nitrate nitrogen: 0.004 (detection level) to 0.017; color: 6 to 25; and hardness: 86 to 715 (moderately hard to very hard).

In Collier County, water quality in the Sandstone Aquifer generally deteriorates in a southwest direction. There is a pocket of poor water quality in the area of northeast Lee and northwest Hendry counties, suggesting the presence of connate water or contamination by short-cased FAS wells as described previously.

Mid-Hawthorn Aquifer

In the mid-Hawthorn aquifer, chlorides, TDS, sodium and hardness continue the trend of increasing with overall depth, resulting in a marked deterioration in water quality from the shallower aquifers. These constituents also share a common overall trend of increasing in the southwesterly direction. Chloride ranges from 28 to 844 mg/L, in excess of potable standards in six of the ten ambient wells. Total dissolved solids range from 263 to 1,591 mg/L, and sodium from 43 to 480 mg/L; both exceed potable standards in all but two of the ten wells.

Concentrations of all other parameters investigated are distinctly lower in the mid-Hawthorn than in the overlying aquifers, as observed in the average ranges (mg/L): iron: 0.050 to 0.463; TOC: 0.7 to 16.5; alkalinity: 144 to 286; nitrate nitrogen: 0.004 (detection level) to 0.006; and color: 3 to 13 units (four wells only).

Lower Hawthorn Aquifer/Floridan Aquifer System

In the LWC Planning Area, AGWQMN wells in the Floridan Aquifer System are limited to lower Hawthorn aquifer wells located in Lee and northern Collier counties. For this reason, water quality contour lines were omitted in the areas where no data existed. Additional data were obtained from other sources to supplement the chloride contour plot, although information on the FAS in Southwest Florida is sparse.

Water quality in the FAS is generally poor, with high levels of chloride, sodium, and TDS, all of which increase with depth and distance from the primary recharge area. Chloride in the lower Hawthorn, the uppermost aquifer of the FAS, ranges from approximately 360 to 1,900 mg/L . Sodium ranges from 221 to 920 mg/L; TDS from 923 to 2,556 mg/L. Water from most of the lower Hawthorn wells is below detection levels for iron and nitrate, and is also very low in color. Hardness ranges from 225 to 691 mg/L (hard to very hard). Alkalinity averages 158 mg/L, ranging from 90 to 200 mg/L.

There are no AGWQMN wells in the LWC Planning Area which penetrate the deeper aquifers of the FAS. In the Cape Coral area, however, the following chloride ranges have been documented: lower Hawthorn: 320 to 3,200 mg/L; upper Suwannee: 480 to 5,600, lower Suwannee: 660 to 13,500 mg/L; Ocala: 1,900 to 20,000; Avon Park: 11,000 to 16,000 mg/L (Missimer & Associates, 1991). Recent information from a lower Hawthorn reverse osmosis well under construction for Marco Island reported chloride concentrations to be 3100 to 4800 mg/L, where levels of 1,500 to 3,000 mg/L had been predicted.

In its Regional Aquifer System Analysis (RASA) Program, the U.S. Geological Survey has further defined the geochemistry of the Floridan Aquifer System in a series of reports (Sprinkle, 1989; Meyer, 1989; Bush and Johnson, 1988; Miller, 1986). Figures F-52 and F-53 illustrate the ranges of chloride concentrations in the upper and lower portions of the FAS throughout the SFWMD (after Sprinkle, 1989). The USGS indicates that in Southwest Florida the lower part of the Tampa Limestone (the lower Hawthorn aquifer) is included as part of the upper portion of the FAS (Meyer, 1989). Also, as indicated in Table D-1, the SFWMD defines the top of the upper portion of the FAS as including the lower Hawthorn aquifer. This definition reflects the fact that, within the LWC Planning Area, the lower Hawthorn often reflects and responds to hydrologic conditions in the Suwannee aquifer, which is part of the FAS, but responds only slightly to hydrologic conditions in the Intermediate Aquifer System.

Information found in the USGS report by Sprinkle (1989) indicates that in the upper portion of the FAS, concentrations of dissolved solids are greater than 1,000 mg/L in most of the LWC Planning Area, increasing in concentration toward the coast. Exceptions are north-central Glades County (Fisheating Creek Area) where it ranges from 501 to 1,000 mg/L, in wells drilled into the upper portion of the FAS. Fully penetrating wells near the coast would likely yield dissolved solids concentrations which would approach seawater concentrations (about 36,000 mg/L). The report indicates that dissolved solids concentrations in water from the lower portion of the FAS in this region are far greater than 10,000 mg/L, except in northeast Glades County where they range from 1,000 to 10,000 mg/L.

It should be noted that this information on water quality in the FAS is based on extrapolation of data from wells which are, with little exception, not located within the LWC Planning Area. Precise determination of water quality from the FAS in this region will require the installation of test wells at sites under consideration for development of the FAS as a water source.

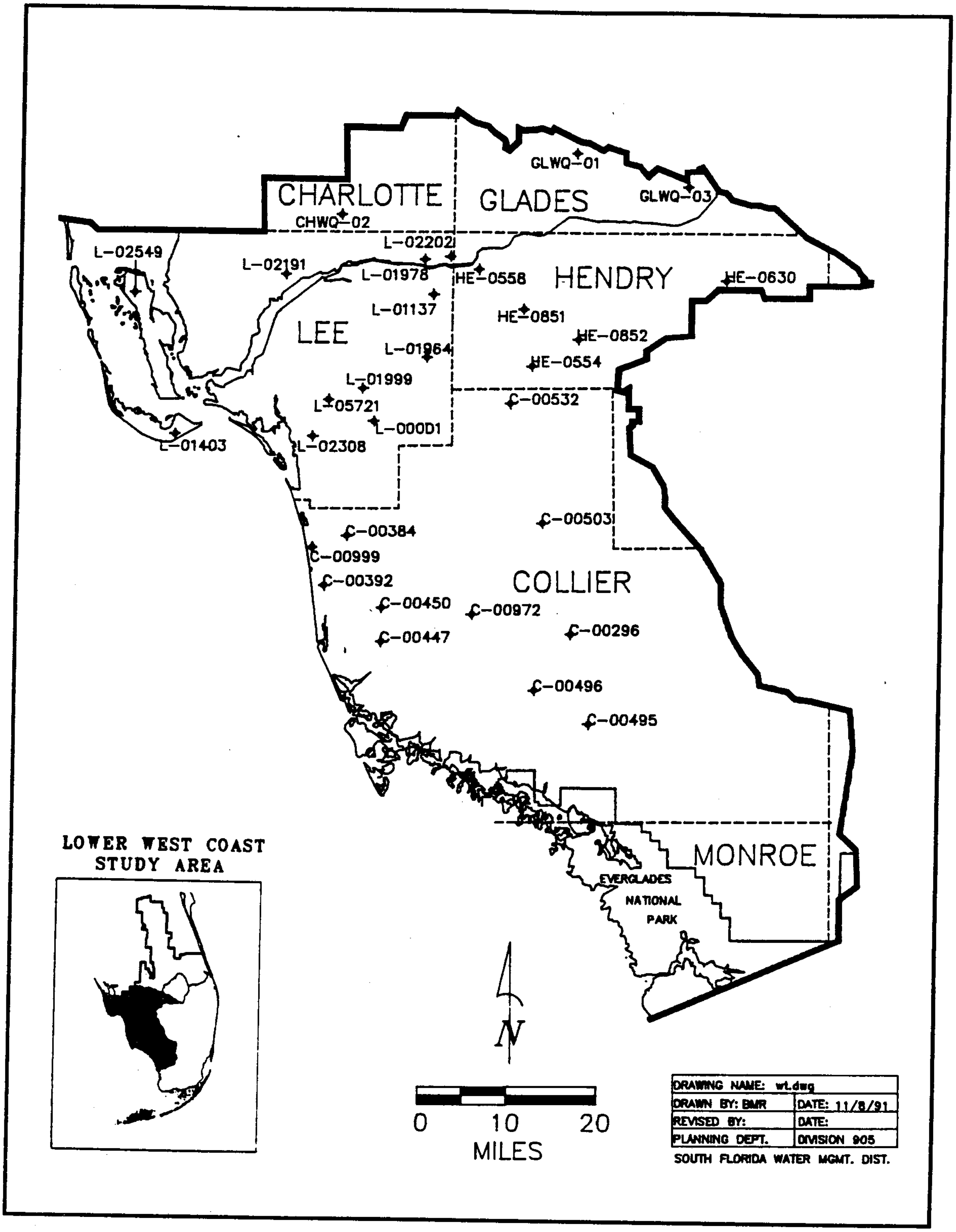

FIGURE H-1. Water Table Aquifer Ambient Ground Water Quality Monitor Wells.

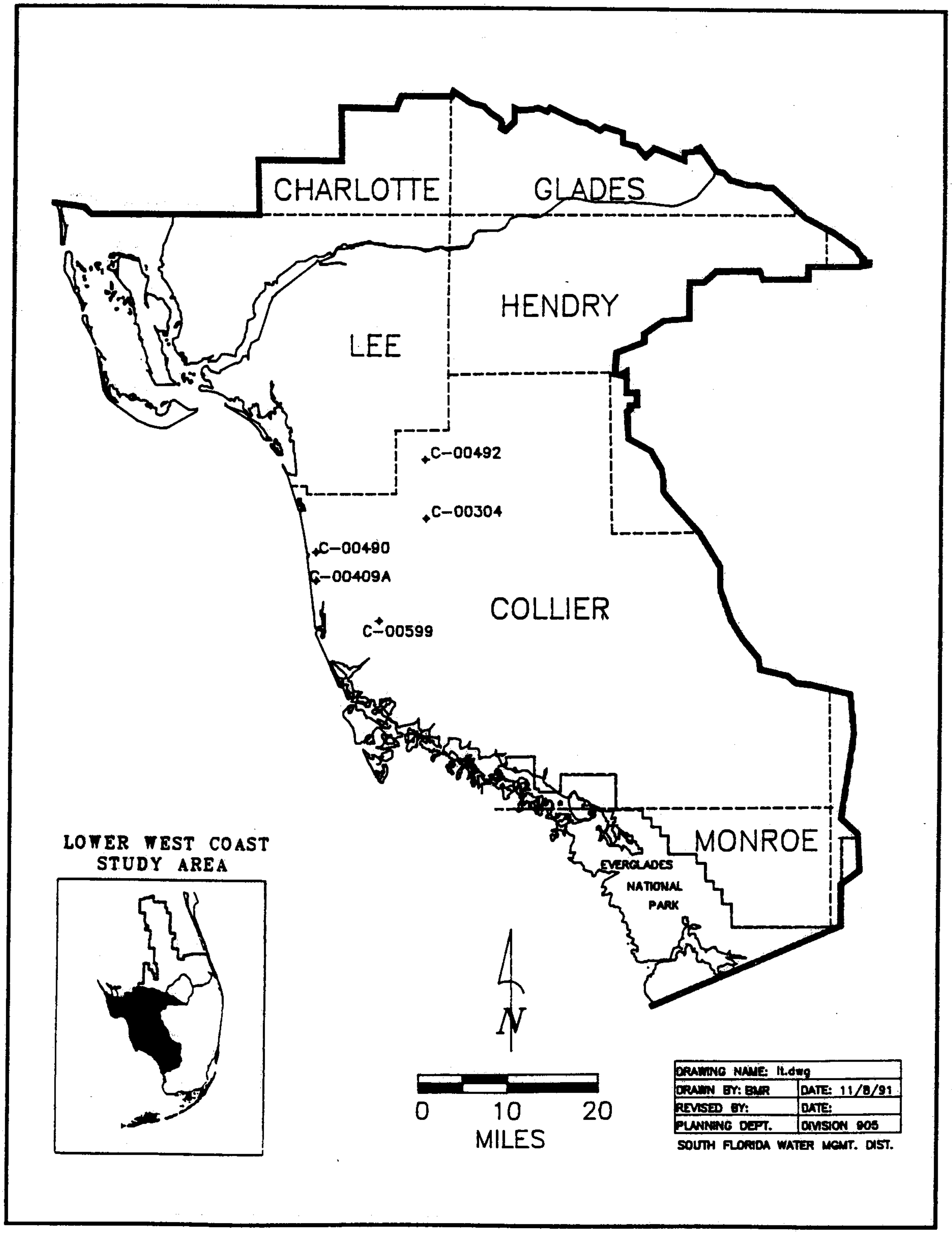

FIGURE H-2. Lower Tamiami Aquifer Ambient Ground Water Quality Monitor Wells.

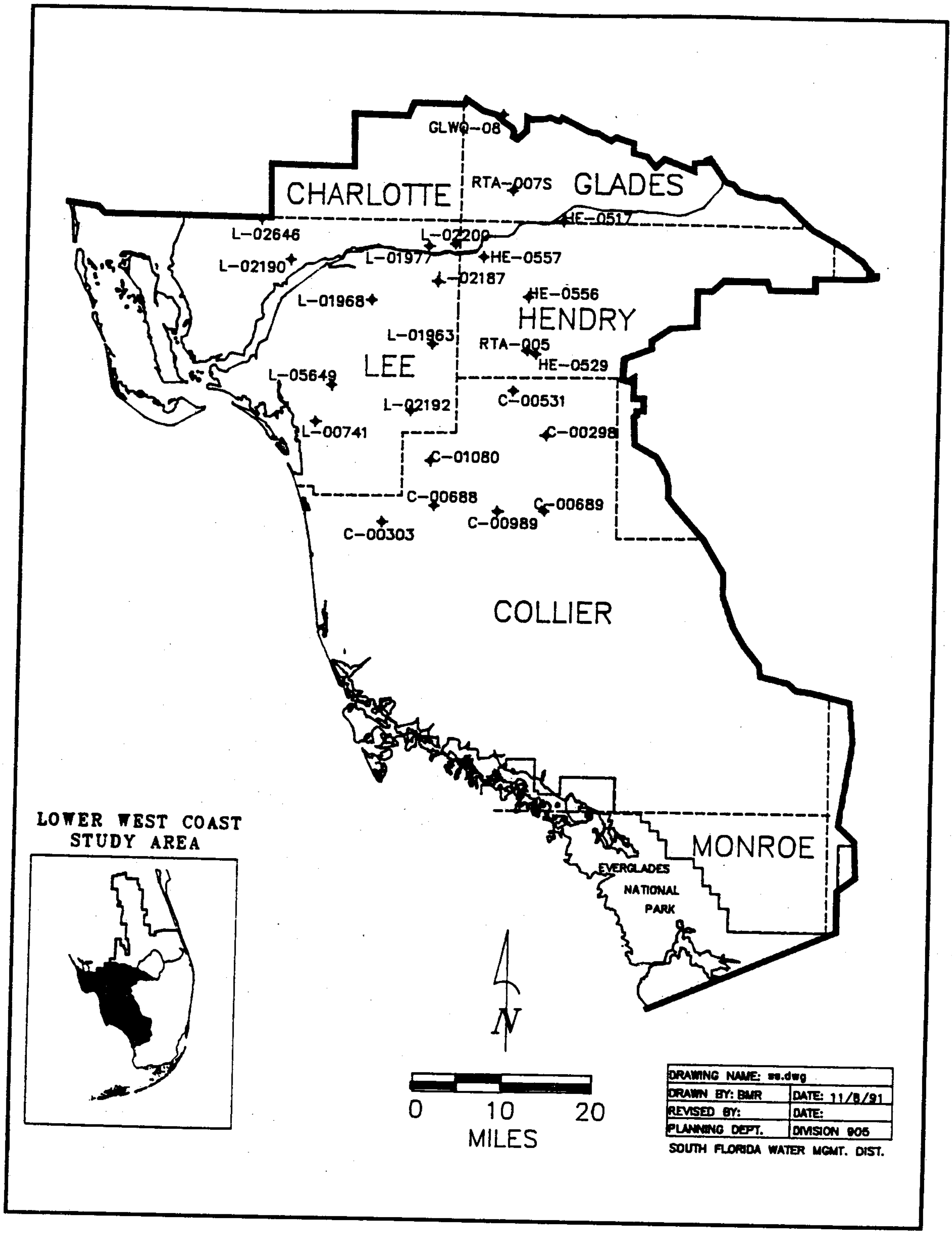

FIGURE H-3. Sandstone Aquifer Ambient Ground Water Quality Monitor Wells.

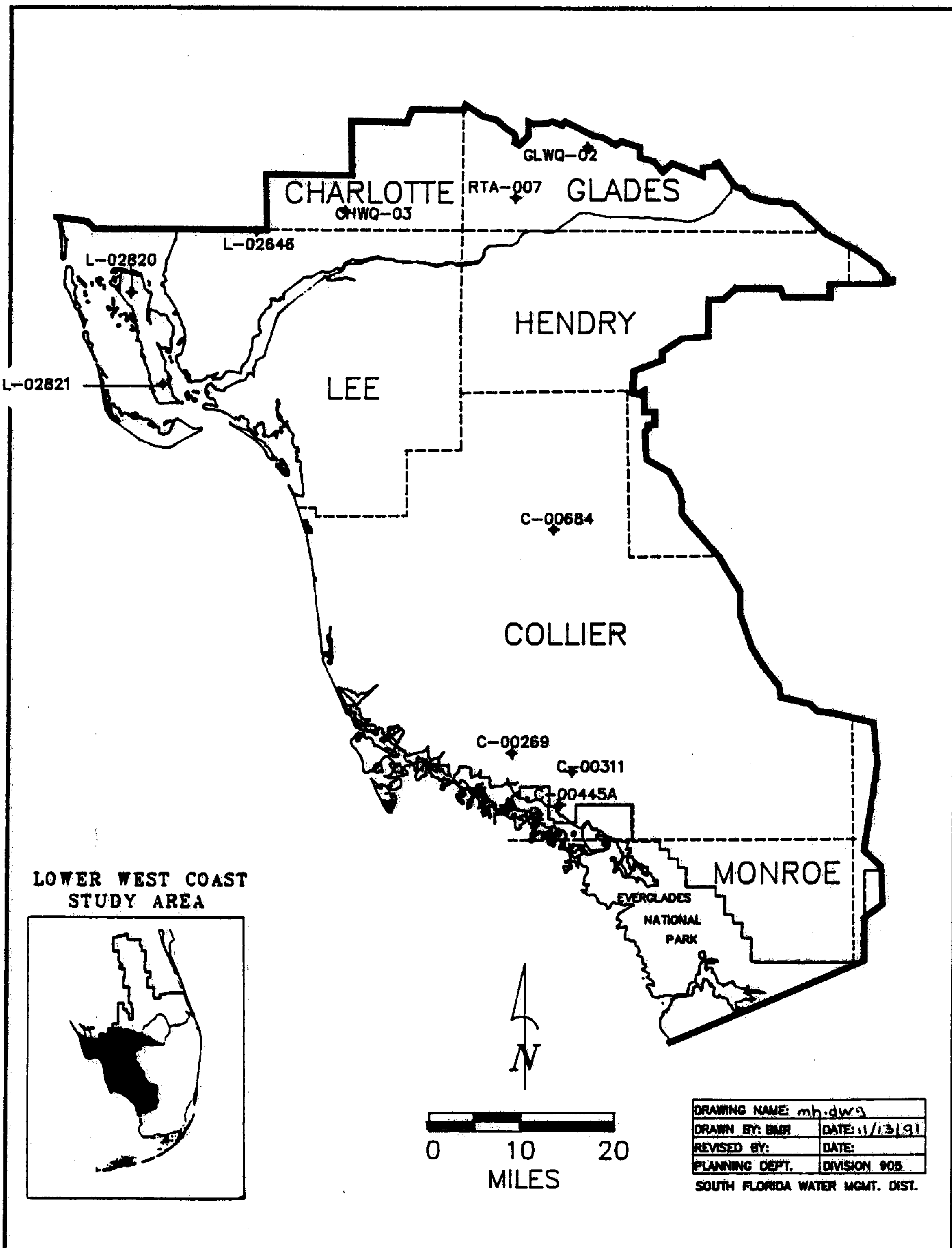

FIGURE H-4. Mid-Hawthorn Aquifer Ambient Ground Water Quality Monitor Wells.

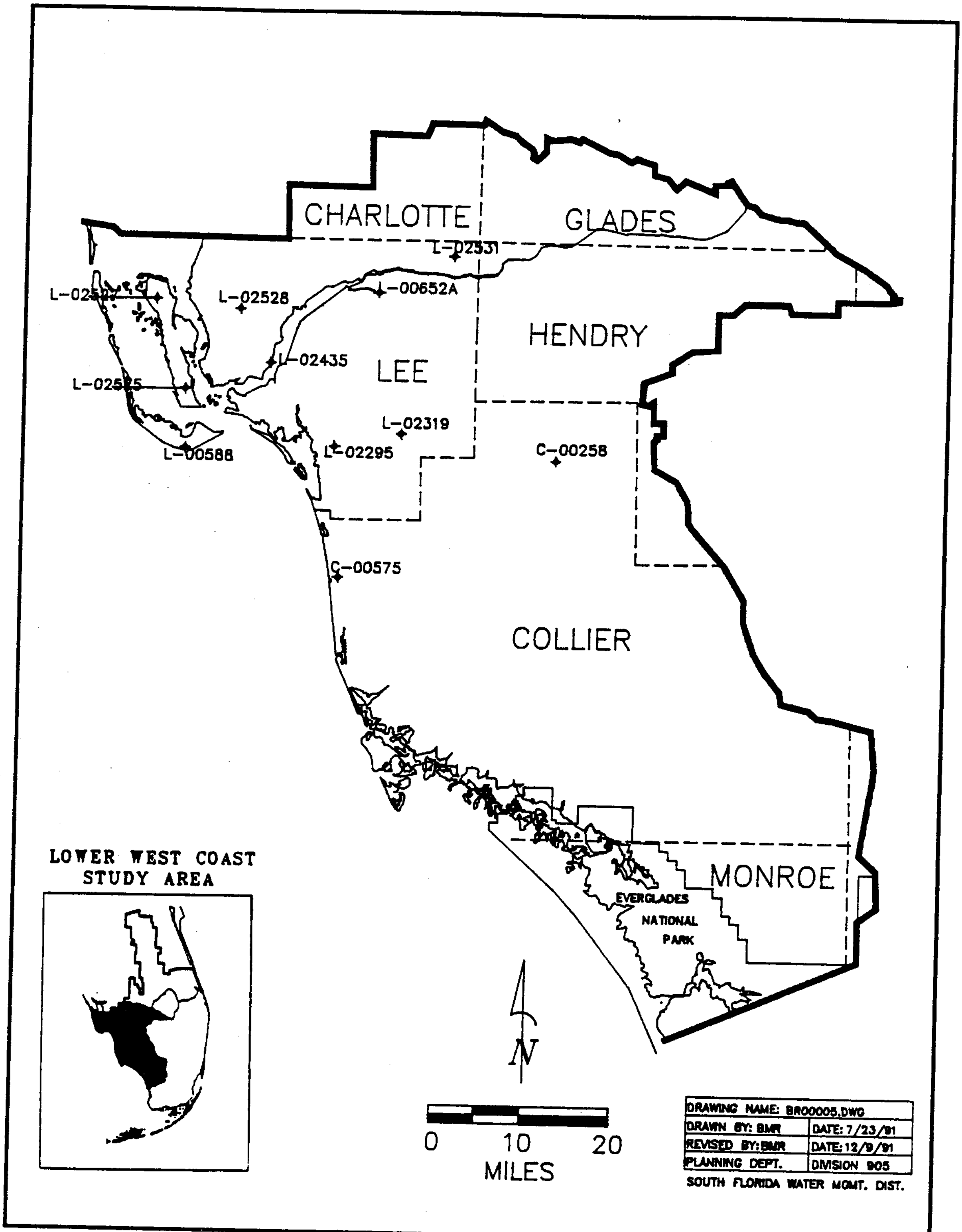

FIGURE H-5. Lower Hawthorn Aquifer Ambient Ground Water Quality Monitor Wells.

TABLE H-1. Water Table Aquifer Ambient Ground Water Quality Monitor Wells.

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
CHWQ-02	249724	896582	18	28	35	385	26	2.997	16	228	0.004	--	257
C-00054	538081	668072*	7	8	23	337	15	1.643	35	270	0.006	--	282
C-00296	386697	646196	8	45	--	601	--	0.842	8	279	0.013	--	406
C-00384	253768	705317	10	10	23	340	11	0.670	7	282	--	24	330
C-00392	240386	675510	23	30	46	344	27	1.415	25	316	0.005	--	315
C-00447	274369	641594	8	26	73	483	45	2.468	18	317	0.011	125	432
C-00450	274659	662088	8	30	40	261	69	0.345	17	315	0.005	88	432
C-00495	397509	592964	8	70	24	222	13	0.455	7	204	0.025	--	211
C-00496	365081	613044	8	60	44	284	22	0.553	18	251	0.006	--	267
C-00503	369492	712981	8	23	44	369	21	3.687	32	244	0.005	64	262
C-00532	350178	784426	3	10	25	319	15	0.653	76	190	0.010	265	216
C-00972	328042	658205	25	44	9	349	9	0.195	13	268	0.014	--	299
C-00999	233332	698170	13	23	16	276	9	1.678	44	216	0.008	--	250
GLWQ-01	388737	933334	39	49	8	48	9	0.458	49	6	0.011	--	5
GLWQ-03	454712	912914	34	44	64	704	44	1.762	54	371	0.014	--	444
GLWQ-06	499095	979529*	31	41	--	981	--	0.358	15	385	0.019	--	438
GLWQ-07	337398	954452*	35	45	155	612	74	5.815	16	206	0.005	--	326
GLWQ-09	388318	979075*	18	28	14	85	11	3.405	49	18	0.014	--	20
HE-0554	362972	806797	5	15	36	259	26	2.065	60	134	0.004	--	144
HE-0558	330785	863963	3	14	--	--	--	3.880	24	180	0.006	--	--
HE-0630	477507	857364	70	75	158	634	48	0.443	9	288	0.006	--	288
HE-0851	357820	840638	5	13	36	522	26	0.130	38	398	0.005	--	394
HE-0852	390528	822669	9	14	36	471	29	--	74	249	0.015	--	258

Water quality data represents average values from multiple sampling events for time period 1984-1990.
*Well located outside of LWC Planning Area; used for background data.

TABLE H-1. (Continued).

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
HE-0854	492737	819194*	3	14	18	371	16	2.397	63	231	0.013	--	286
HE-0856	458673	797002*	4	11	5	218	3	0.558	49	182	0.019	--	181
HE-0862	534583	712188*	7	11	19	311	20	2.800	44	259	0.011	--	245
L-00001	269436	773685	0	35	64	346	17	2.920	10	230	0.004	--	255
L-01137	304234	849034	15	20	15	342	29	3.875	33	238	0.010	142	213
L-01403	151756	765609	2	11		756	--	0.340	12	294	0.012	--	350
L-01964	300519	811995	14	24	27	375	18	2.120	40	275	0.017	203	273
L-01978	298800	869759	7	17	41	329	16	1.700	38	201	0.014	--	224
L-01999	262912	793310	16	26	19	403	21	1.995	44	308	0.013	59	314
L-02191	216948	861046	15	20	25	518	12	2.863	20	253	0.006	--	329
L-02202	314041	871505	7	19	58	464	25	4.037	65	290	0.004	--	320
L-02308	233386	764508	12	13	23	314	11	3.340	48	245	0.010	123	251
L-02549	127505	849935	58	80	102	535	36	0.190	50	307	0.016	22	365
L-05721	242522	786766	0	30	42	384	20	2.615	34	230	0.004	117	272

Water quality data represents average values from multiple sampling events for time period 1984-1990.
*Well located outside of LWC Planning Area; used for background data.

TABLE H-2. Lower Tamiami Aquifer Ambient Ground Water Quality Monitor Wells.

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
C-00304	237526	669570	63	73	25	222	12	0.210	7	205	0.008	--	224
C-00409A	301731	741716	60	64	55	432	28	2.220	46	263	0.004	--	307
C-00490	274481	645632	40	50	155	647	87	0.050	14	340	0.005	--	467
C-00492	302204	706578	125	130	41	376	42	0.150	12	251	0.004	20	260
C-00599	237539	686533	70	71	12	204	9	0.370	6	174	0.008	39	179
HE-0855	458673	797002*	70	90	98	526	65	0.208	54	316	0.009	--	311

Water quality data represents average values from multiple sampling events for time period 1984-1990.
*Well located outside of LWC Planning Area; used for background data.

TABLE H-3. Sandstone Aquifer Ambient Ground Water Quality Monitor Wells.

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
C-00298	369813	758009	254	303	63	308	69	0.365	4	220	0.005	6	140
C-00303	273977	705204	232	300	676	1533	369	0.310	5	227	0.004	20	455
C-00531	350178	784426	210	237	47	423	60	0.107	21	293	0.004	--	230
C-00689	369492	712880	230	265	81	430	62	0.107	12	275	0.004	18	238
C-00989	342095	712266	240	270	205	797	208	0.060	26	252	0.004	--	173
C-01080	301812	742221	238	309	26	258	65	0.050	1	178	0.005	--	86
C-00688	304520	715351	220	405	45	416	74	0.068	14	267	0.005	18	216
GLWQ-04	463481	996105*	60	70	130	796	96	0.260	39	419	0.017	--	443
GLWQ-08	340725	949243	70	80	111	955	114	0.348	34	433	0.014	--	522
HE-0517	377733	885708	128	138	30	368	17	--	18	295	0.005	--	283
HE-0529	362972	806797	135	155	45	416	39	0.288	28	288	0.005	--	273
HE-0556	357820	840638	135	175	207	689	138	0.160	24	249	0.005	21	284
HE-0557	330784	863962	80	100	--	--	593	0.087	23	122	0.004	22	715
HE-0861	534583	712188*	37	44	69	507	59	0.280	44	363	0.021	--	318
RTA-005	357712	808834	165	200	61	448	44	0.100	21	296	0.004	--	303
RTA-007S	347436	903781	60	80	111	514	114	0.123	21	184	0.009	--	165
L-00741	233386	764508	102	119	162	478	39	1.593	37	144	0.005	7	274
L-01963	301881	811989	65	74	185	678	105	0.355	12	287	0.004	25	353
L-01968	265433	838026	70	165	75	469	46	0.150	20	282	0.004	20	300
L-01977	298800	869759	65	185	1010	2139	514	0.157	17	126	0.004	--	705
L-02187	304234	849034	136	154	350	1016	190	0.138	27	223	0.004	15	424

Water quality data represents average values from multiple sampling events for time period 1984-1990.
*Well located outside of LWC Planning Area; used for background data.

TABLE H-3. (Continued).

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
L-02190	216948	861046	71	109	249	708	100	0.245	12	230	0.004	--	407
L-02192	289875	771761	155	180	78	503	90	0.442	11	286	0.006	21	215
L-02200	314041	871505	122	163	867	1880	413	0.045	23	127	0.004	--	655
L-02646	199160	884598	170	220	81	374	38	0.066	22	193	0.004	--	226
L-05649	242522	786766	118	135	--	730	74	0.240	33	196	0.006	22	376

Water quality data represents average values from multiple sampling events for time period 1984-1990.

TABLE H-4. Mid-Hawthorn Aquifer Ambient Ground Water Quality Monitor Wells.

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
CHWQ-03	249724	896582	175	240	462	977	189	0.050	4.7	167	0.006	--	446
C-00311	380022	573222	430	450	441	1015	447	0.160	0.8	286	0.004	5	205
C-00445A	373117	554060	346	467	701	1235	480	0.463	2.5	231	0.004	--	448
C-00684	369492	712880	440	490	166	--	373	0.237	16.5	190	0.003	11	--
C-00269	345546	584235	300	392	547	1071	351	0.130	0.7	237	0.004	--	358
GLWQ-02	388737	933334	360	460	28	263	43	0.038	0.7	193	0.004	--	146
L-02646	199160	884598	170	220	81	374	38	0.066	21.5	193	0.004	--	226
L-02820	127505	849935	192	250	844	1591	374	0.038	9.8	144	0.005	13	552
L-02821	145296	797370	290	340	591	1402	314	0.103	9.9	162	0.004	3	508
RTA-007	347436	903781	395	410	109	511	119	0.095	3.0	183	0.005	--	161

Water quality data represents average values from multiple sampling events for time period 1984-1990.

TABLE H-5. Lower Hawthorn Aquifer Ambient Ground Water Quality Monitor Wells.

WELL CONSTRUCTION DATA					AVERAGE VALUES OF AVAILABLE DATA								
WELL #	EASTING	NORTHING	CASING DEPTH	TOTAL DEPTH	Chloride mg/L	TDS mg/L	Sodium mg/L	Iron mg/L	TOC mg/L	Alkalin mg/L	Nitrate N mg/L	Color units	Hardness mg/L
C-00575	237087	687040	345	640	1015	2556	657	.05	--	195	0.004	--	--
L-00588	145911	762527	403	557	976	2153	560	--	--	155	0.004	--	--
L-02295	233386	764508	300	610	497	924	350	.05	--	195	0.004	3	--
L-02525	145296	797370	405	645	444	1127	221	.05	--	150	0.004	3	--
L-02527	127505	849935	360	605	1937	3568	830	.05	--	130	0.004	7	--
L-02528	176732	844779	420	625	927	1945	456	.05	--	145	0.004	6	--
L-02531	301557	877419	345	605	789	1849	421	.07	--	90	0.004	--	--

Water quality data represents average values from multiple sampling events for time period 1984-1990.

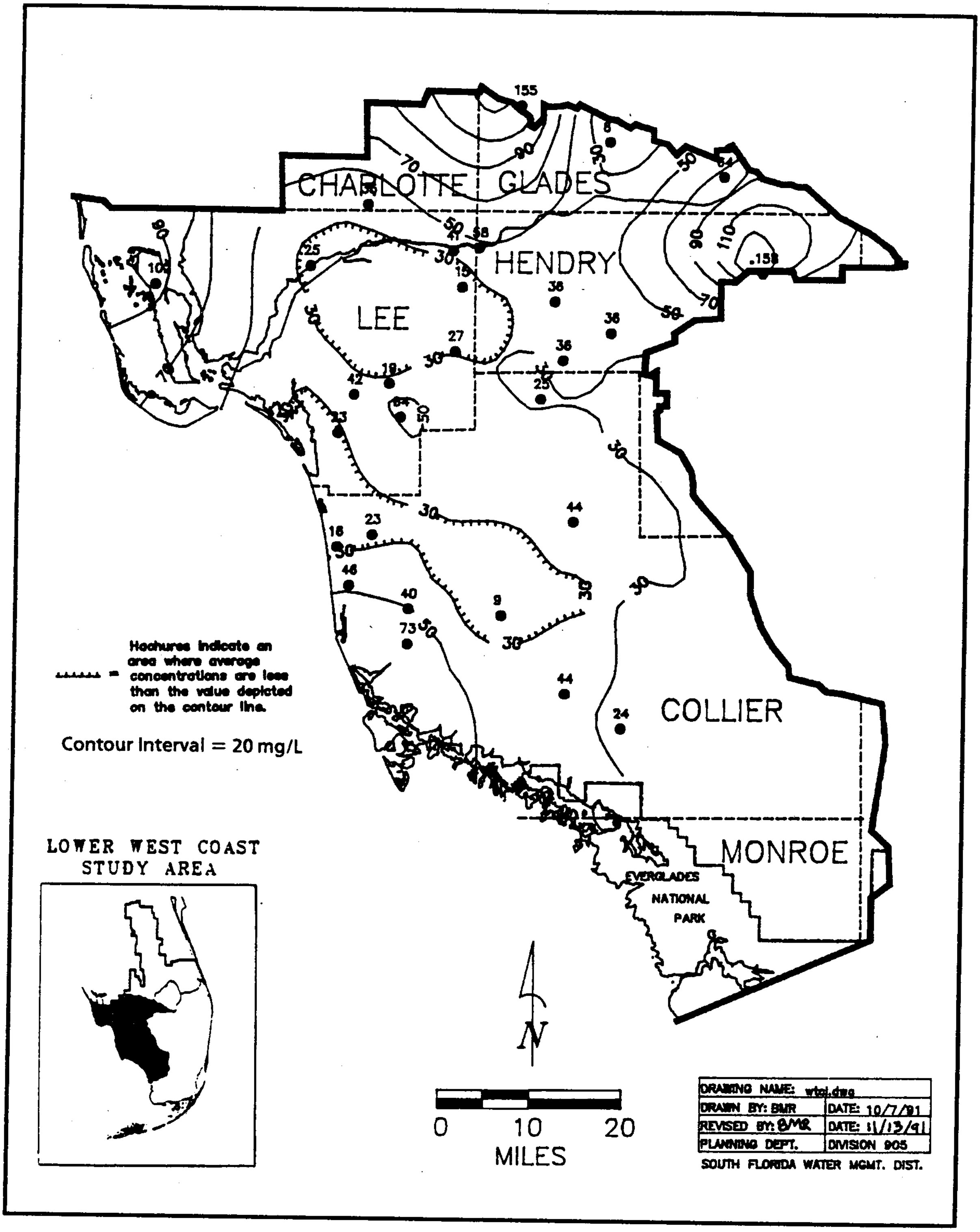

FIGURE H-6. Average Chloride Concentrations (mg/L) of the Water Table Aquifer (1984 - 1990).

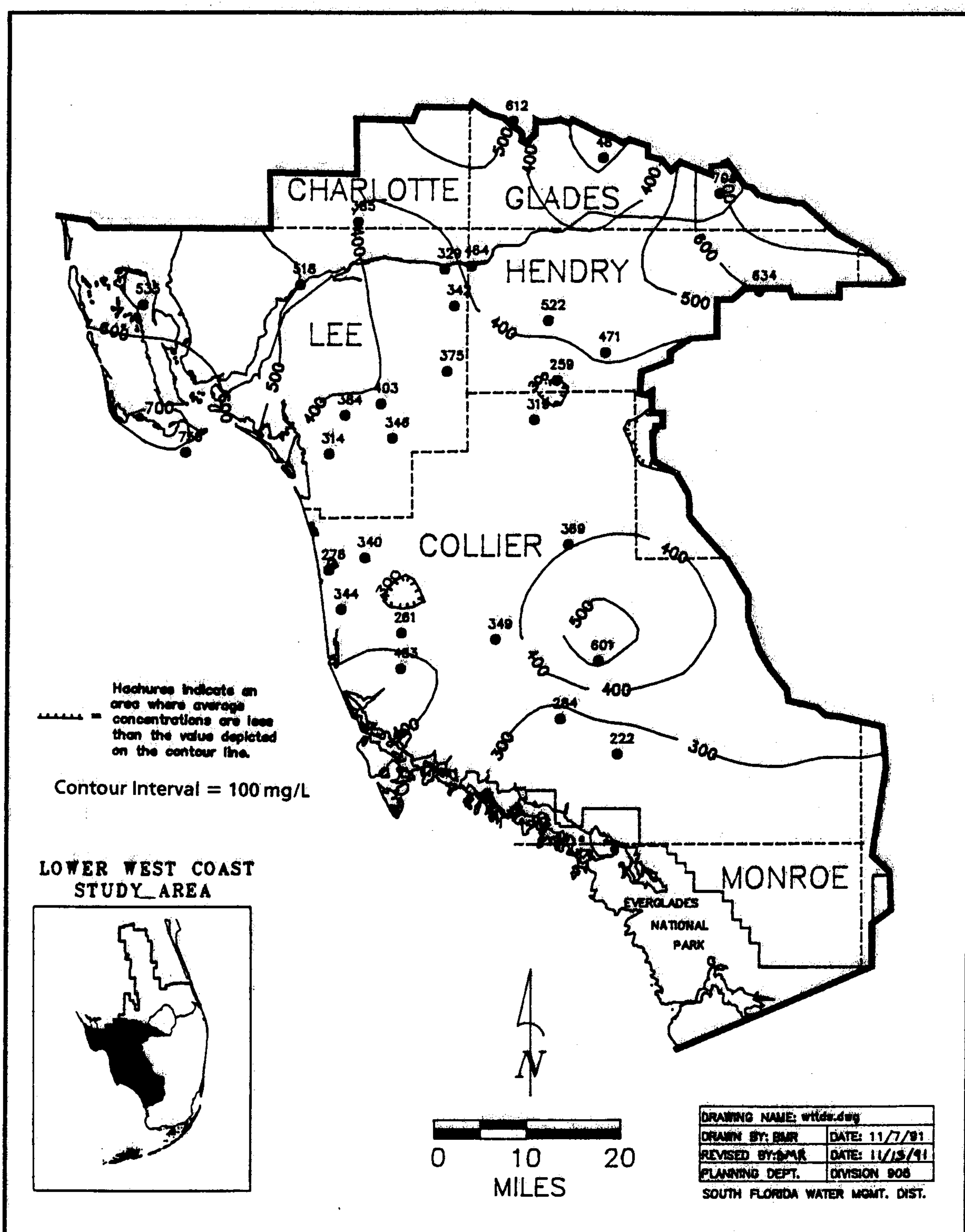

FIGURE H-7. Average Total Dissolved Solids (mg/L) of the Water Table Aquifer (1984 to 1990).

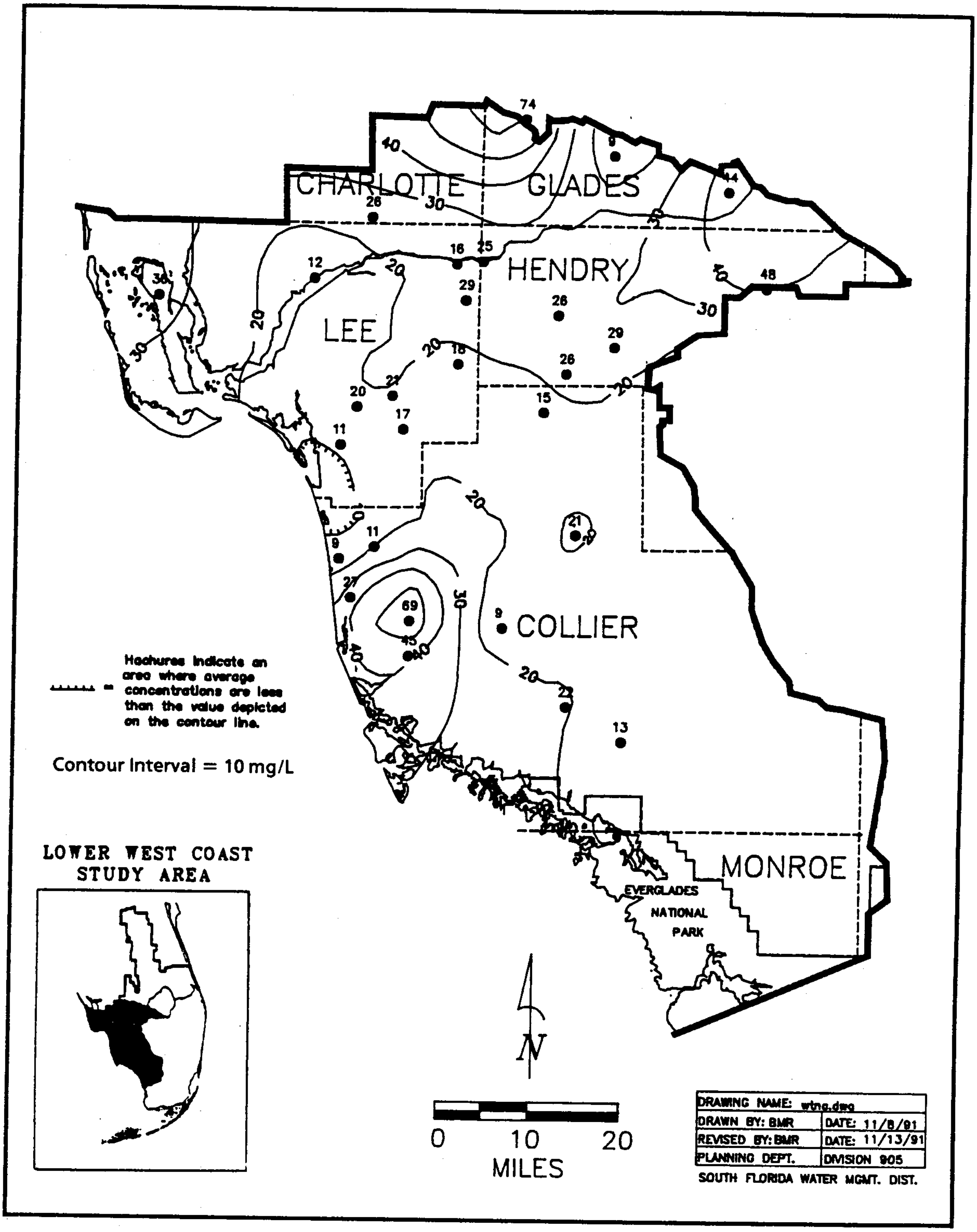

FIGURE H-8. Average Sodium Concentrations (mg/L) of the Water Table Aquifer (1984 to 1990).

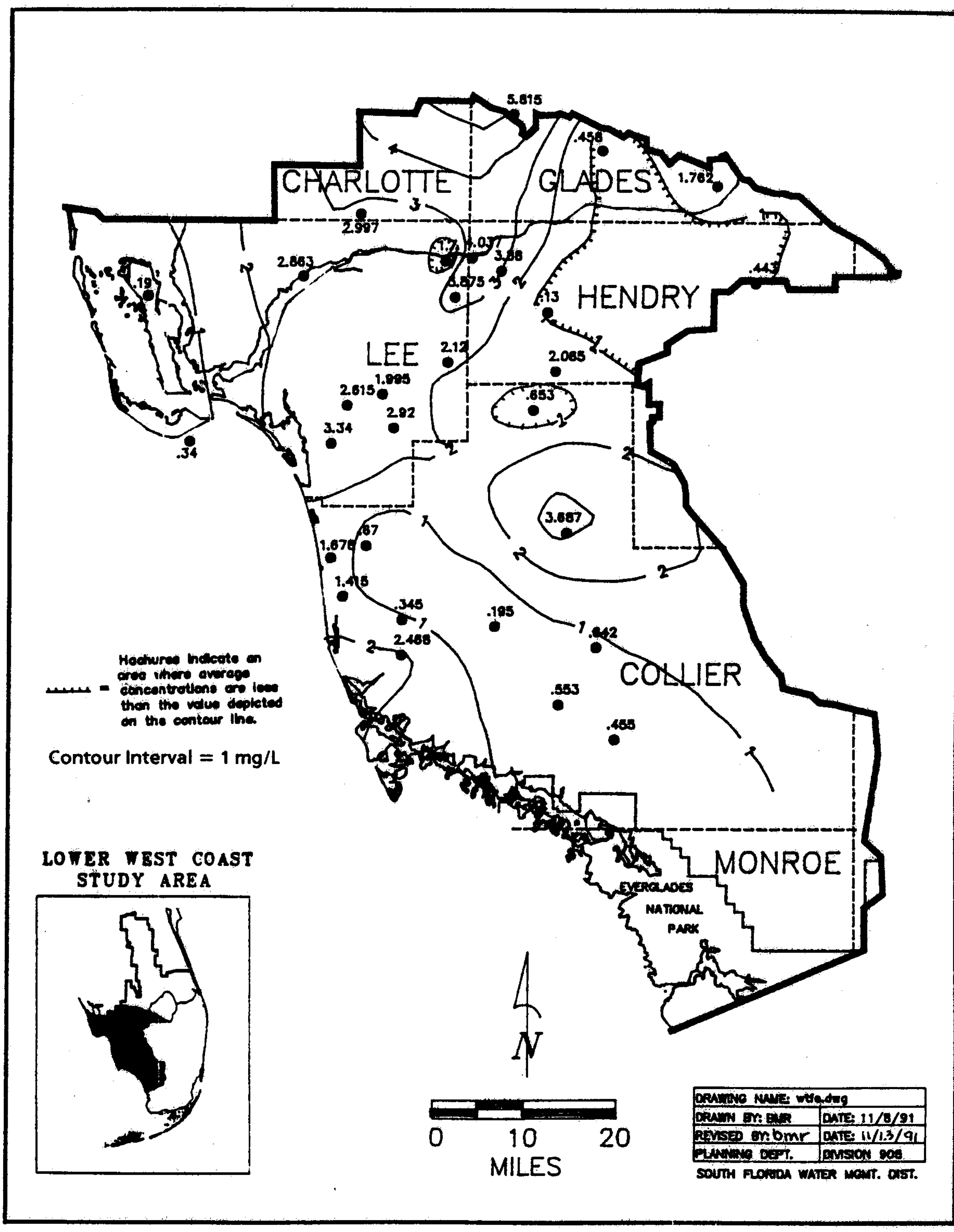

FIGURE H-9. Average Iron Concentrations (mg/L) of the Water Table Aquifer (1984 to 1990).

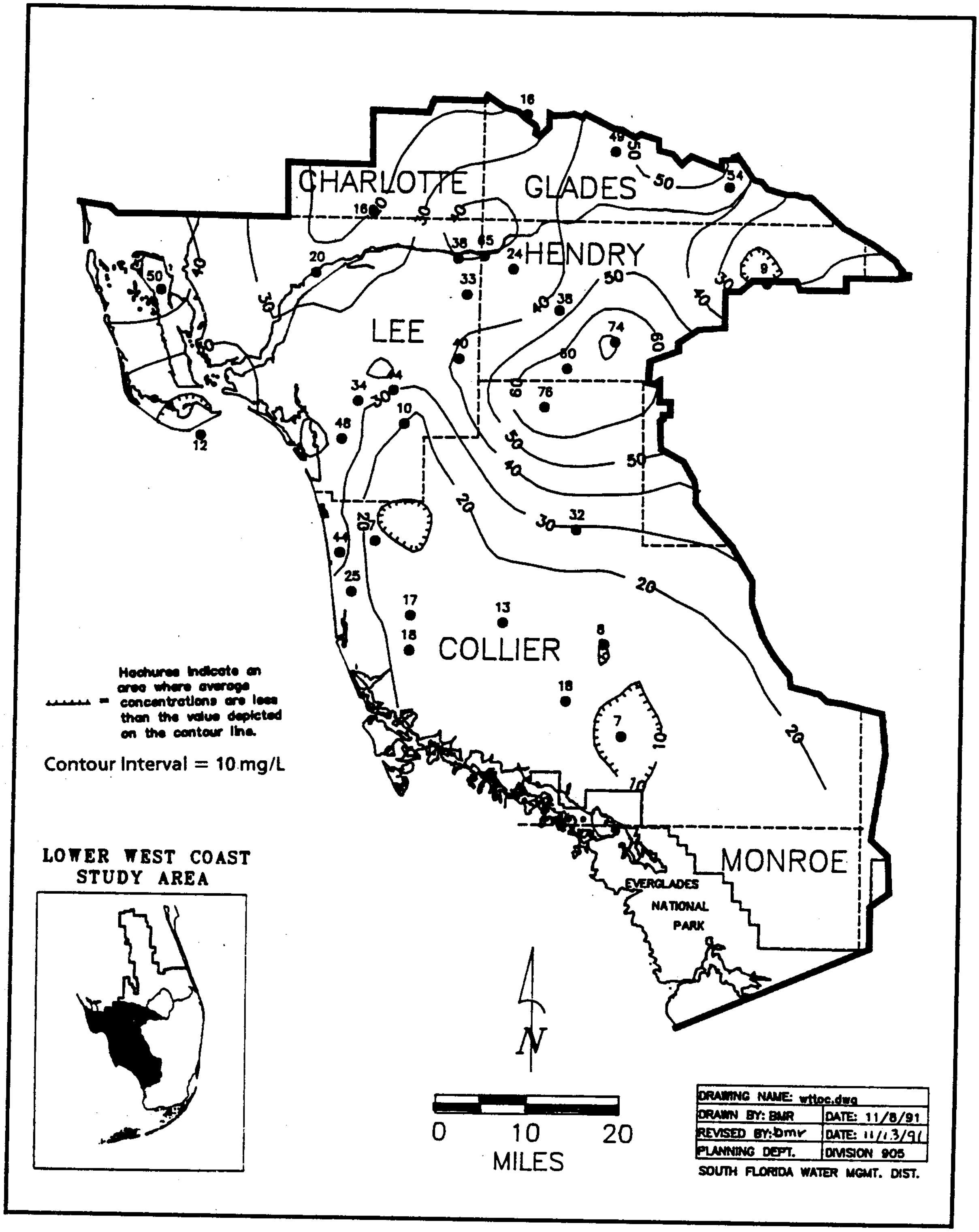

FIGURE H-10. Average Total Organic Carbon (mg/L) of the Water Table Aquifer (1984 to 1990).

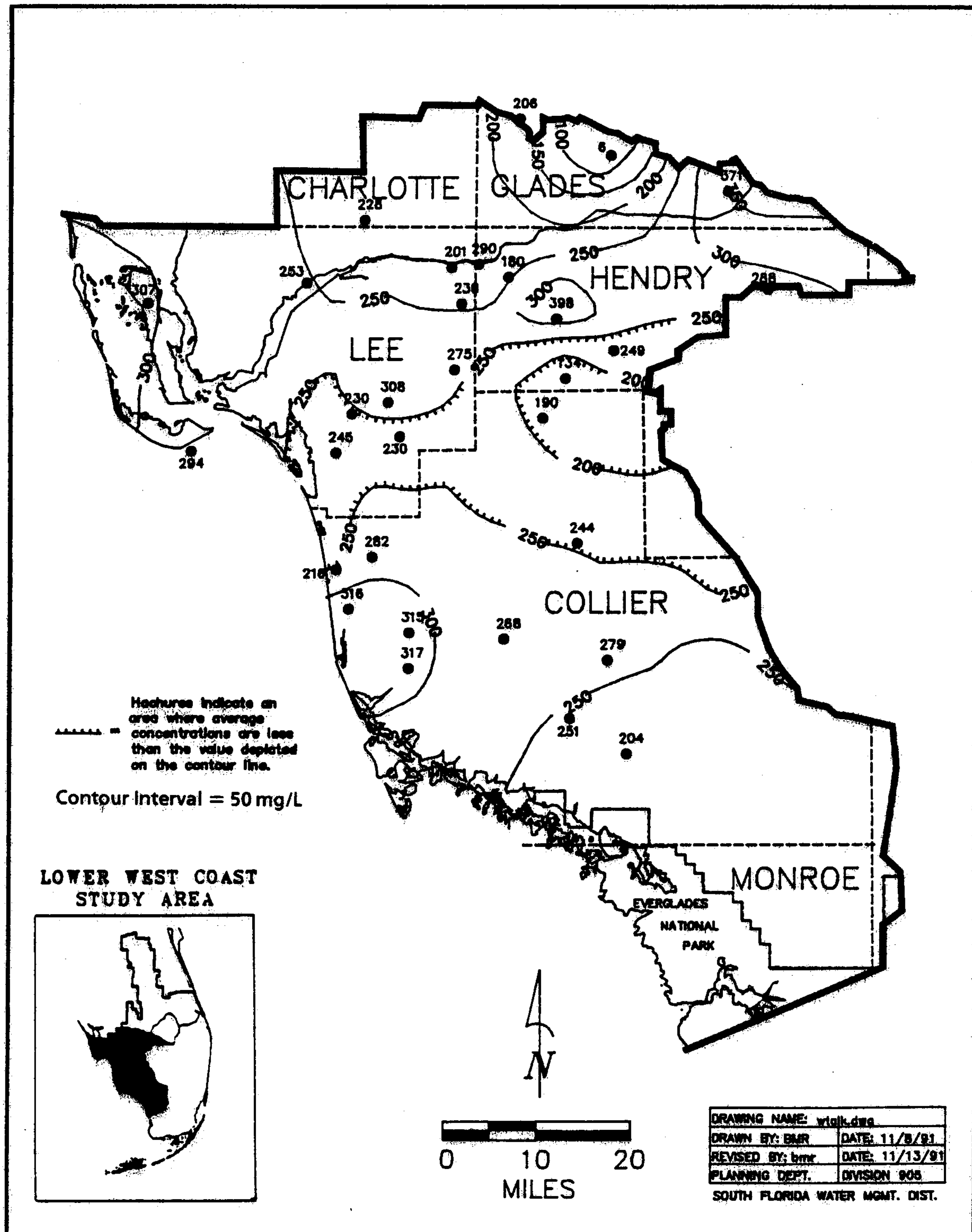

FIGURE H-11. Average Alkalinity (as mg/L of HCO_3) of the Water Table Aquifer (1984 to 1990).

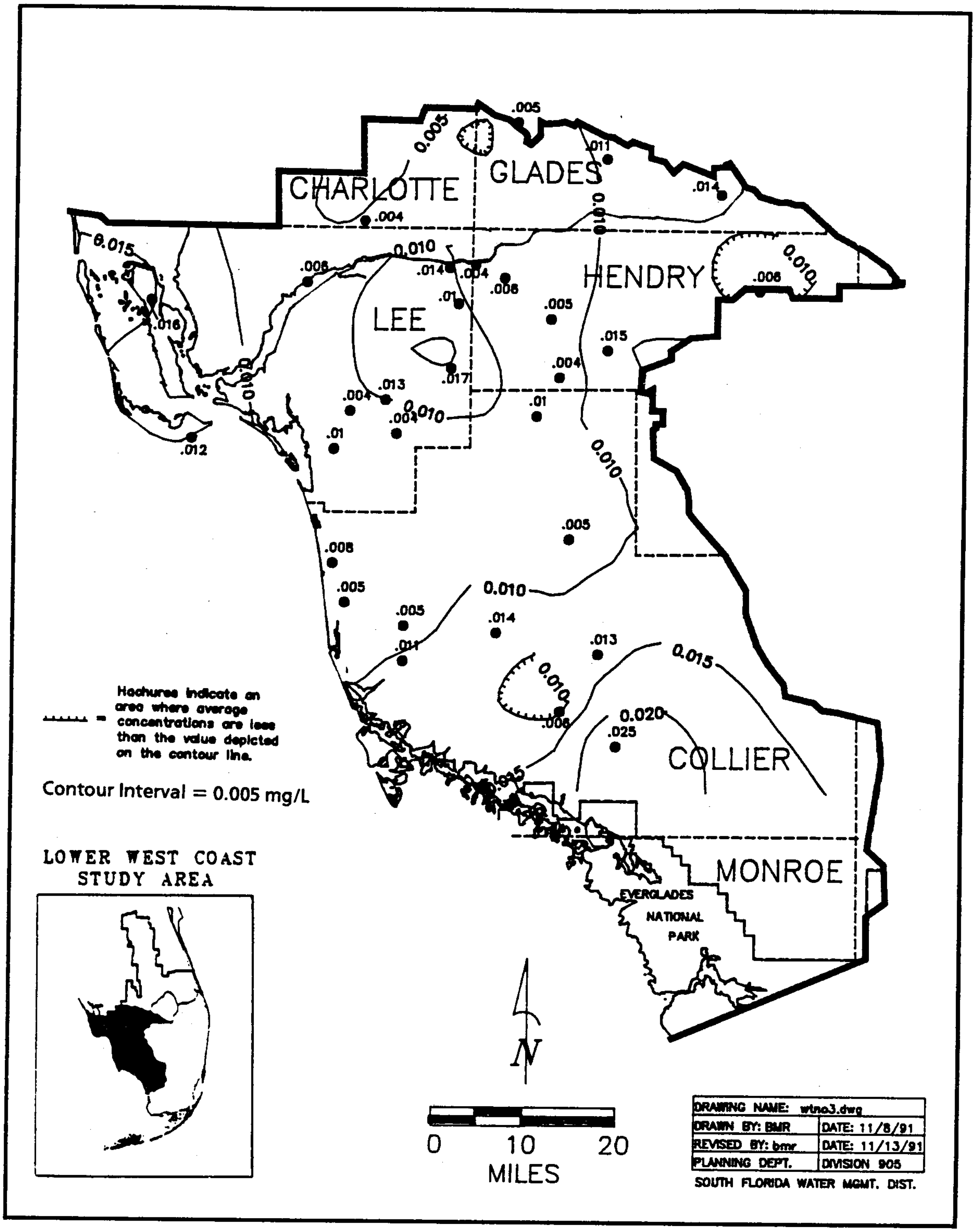

FIGURE H-12. Average Nitrate Nitrogen Concentrations (mg/L) of the Water Table Aquifer (1984 - 1990).

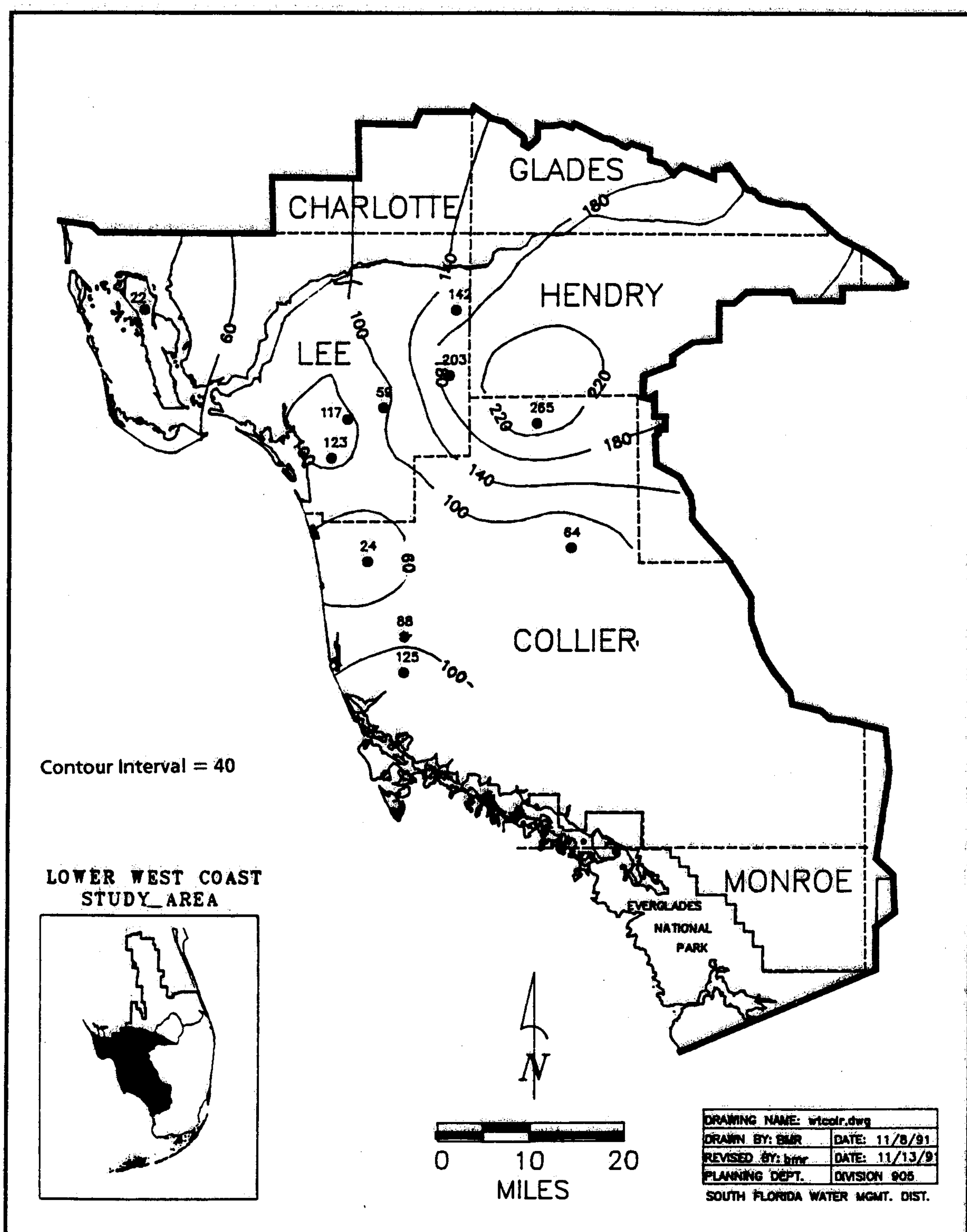

FIGURE H-13. Average Color (units) of the Water Table Aquifer (1984 to 1990).

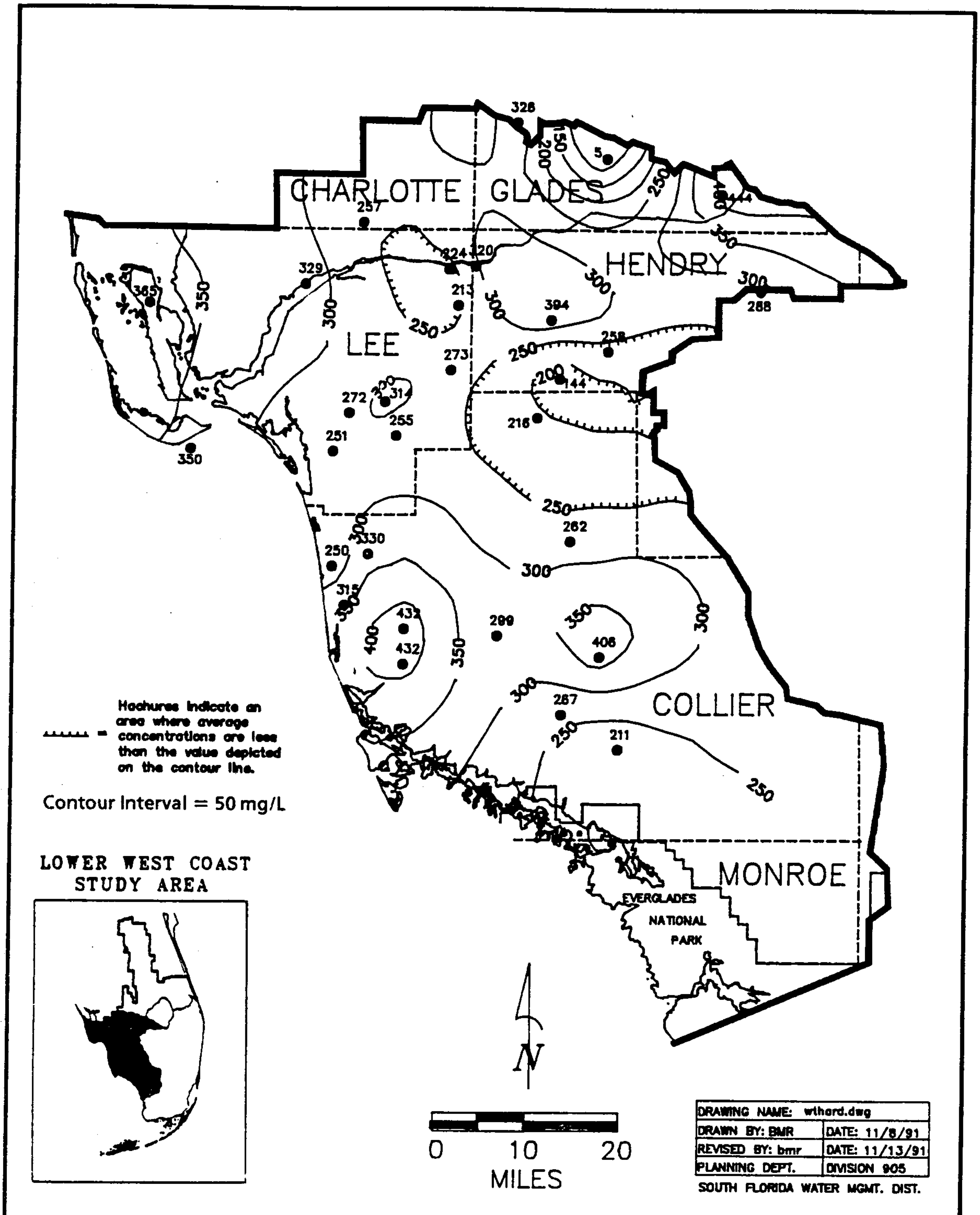

FIGURE H-14. Average Hardness (as mg/L of $CaCO_3$) of the Water Table Aquifer (1984 to 1990).

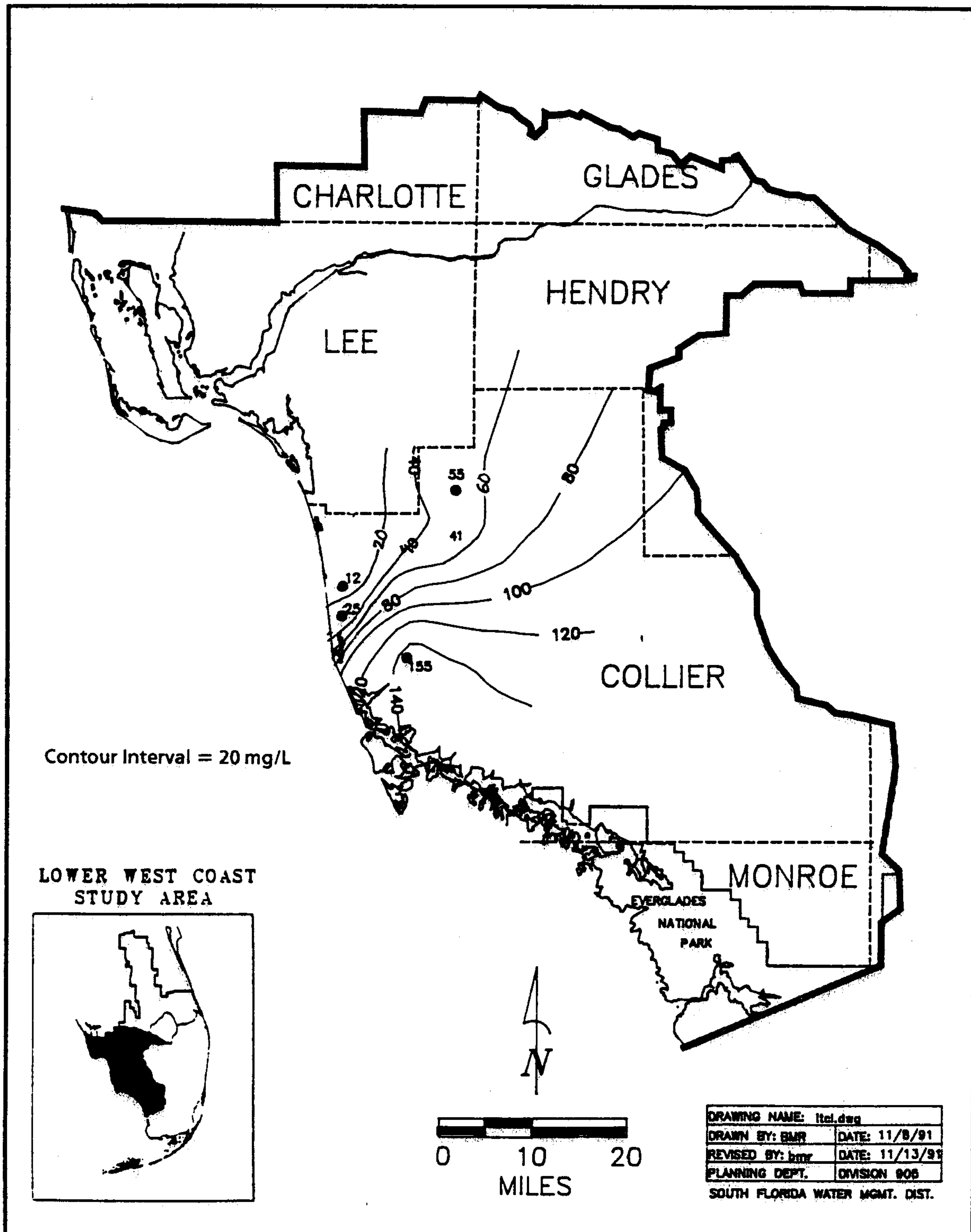

FIGURE H-15. Average Chloride Concentrations (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

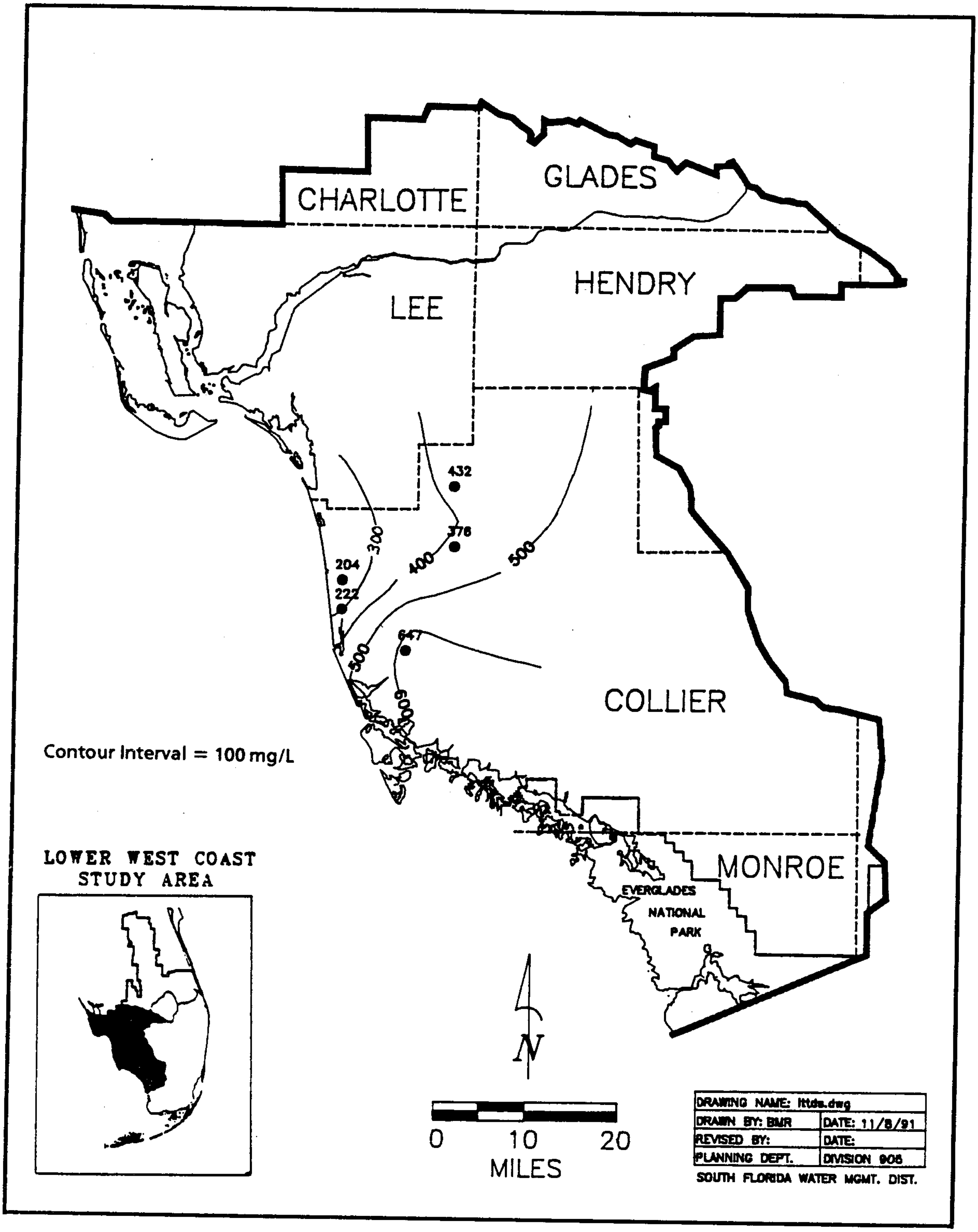

FIGURE H-16. Average Total Dissolved Solids (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

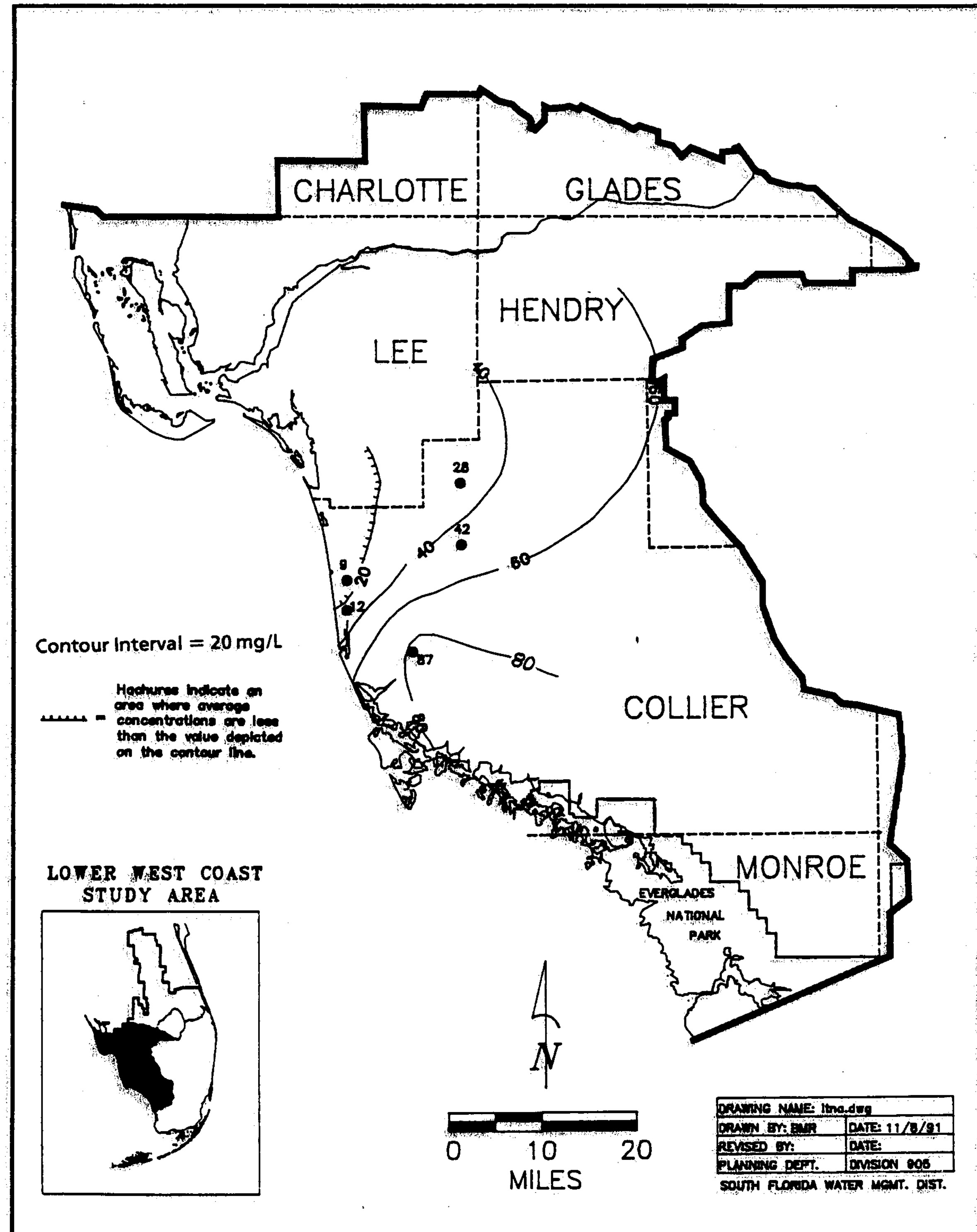

FIGURE H-17. Average Sodium Concentrations (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

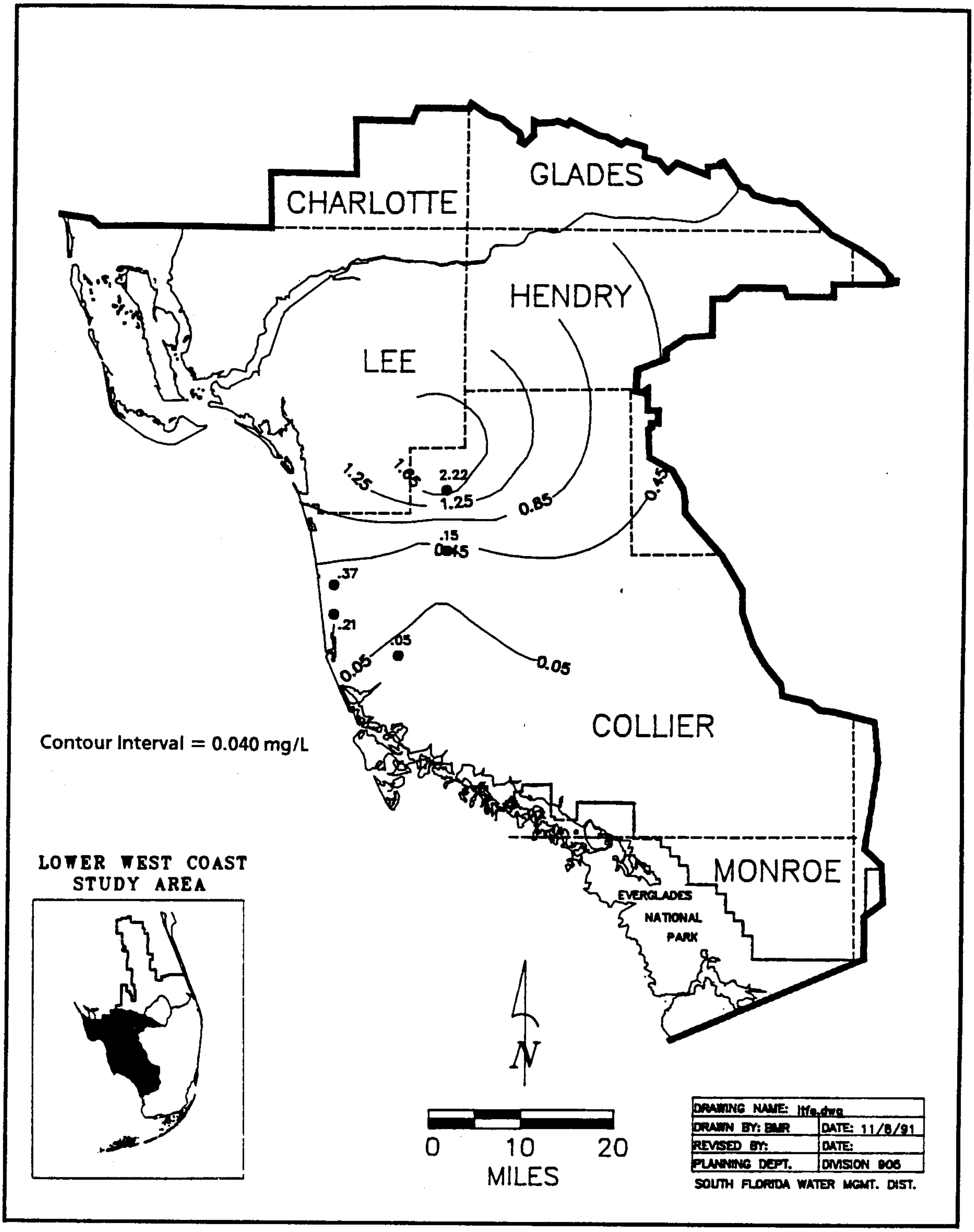

FIGURE H-18. Average Iron Concentrations (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

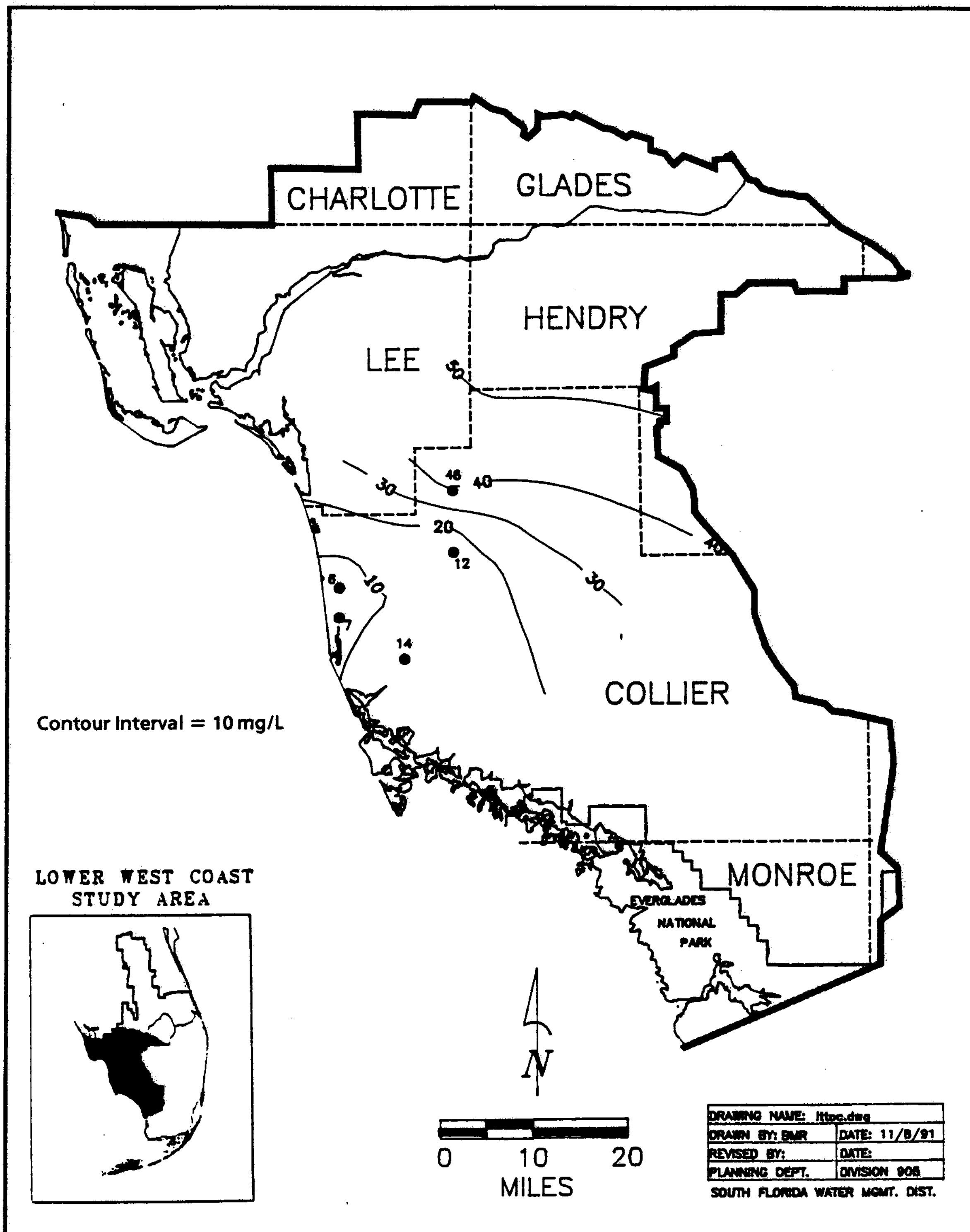

FIGURE H-19. Average Total Organic Carbon (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

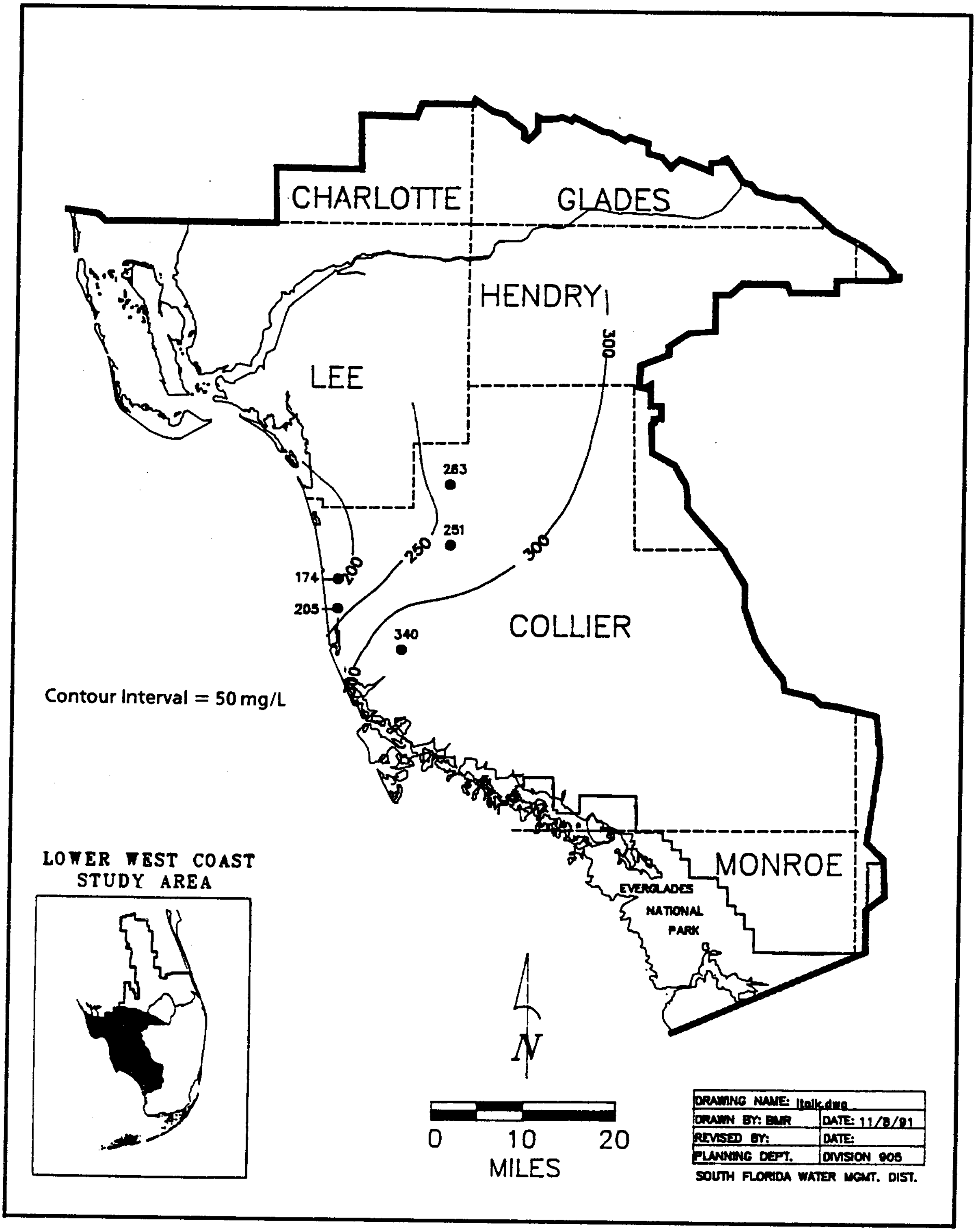

FIGURE H-20. Average Alkalinity (as mg/L of HCO_3) of the Lower Tamiami Aquifer (1984 to 1990).

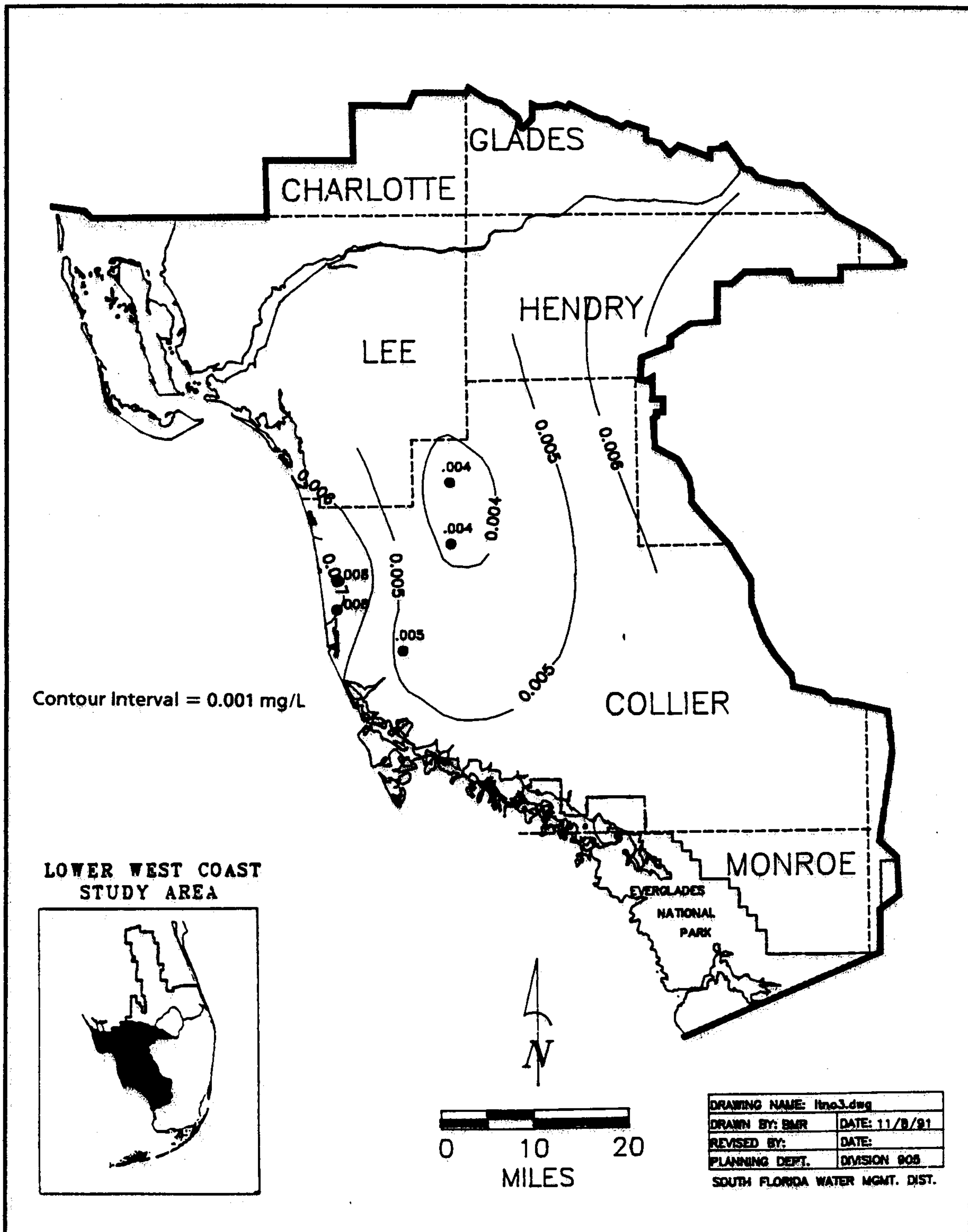

FIGURE H-21. Average Nitrate Nitrogen Concentrations (mg/L) of the Lower Tamiami Aquifer (1984 to 1990).

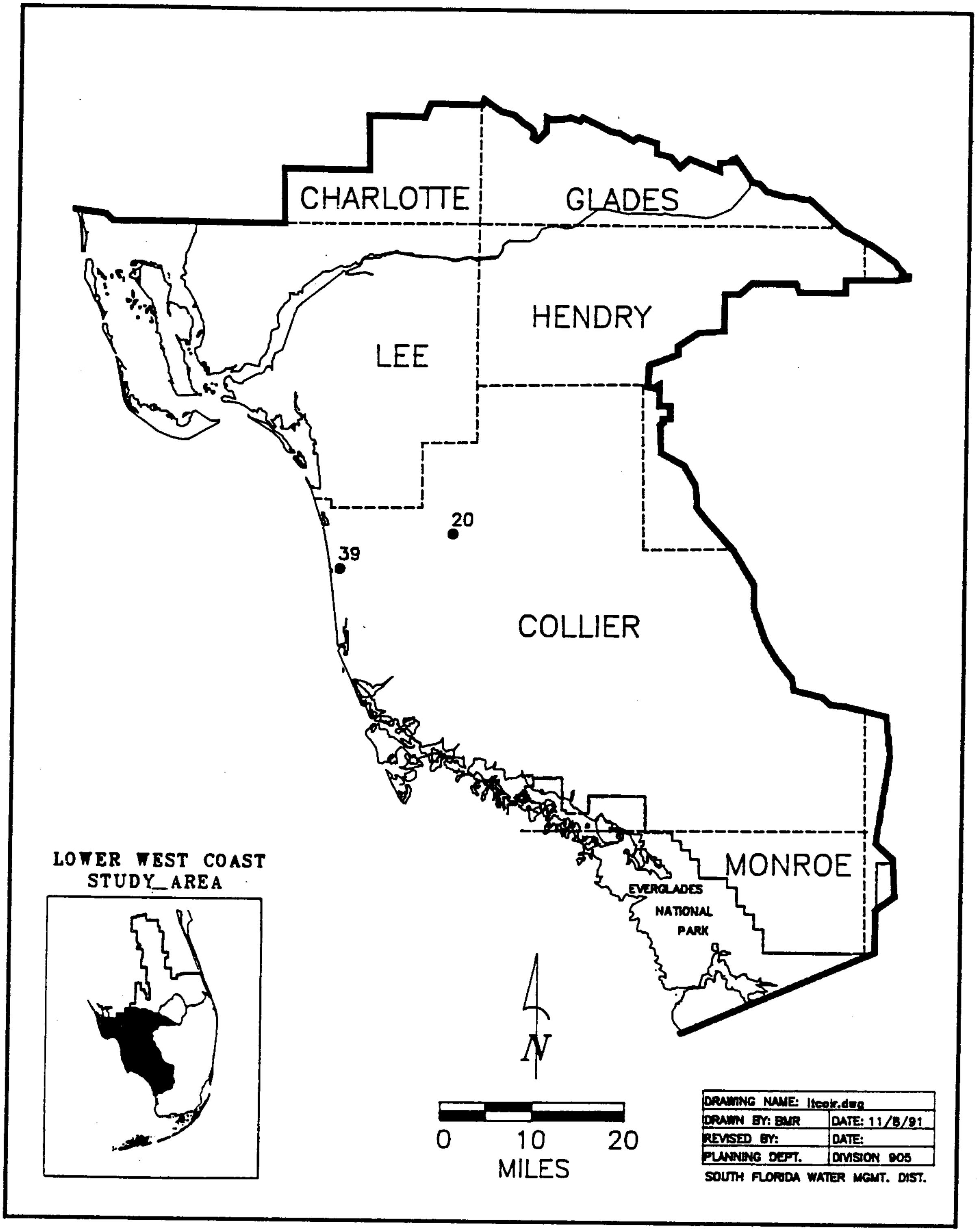

FIGURE H-22. Average Color (units) of the Lower Tamiami Aquifer (1984 to 1990).

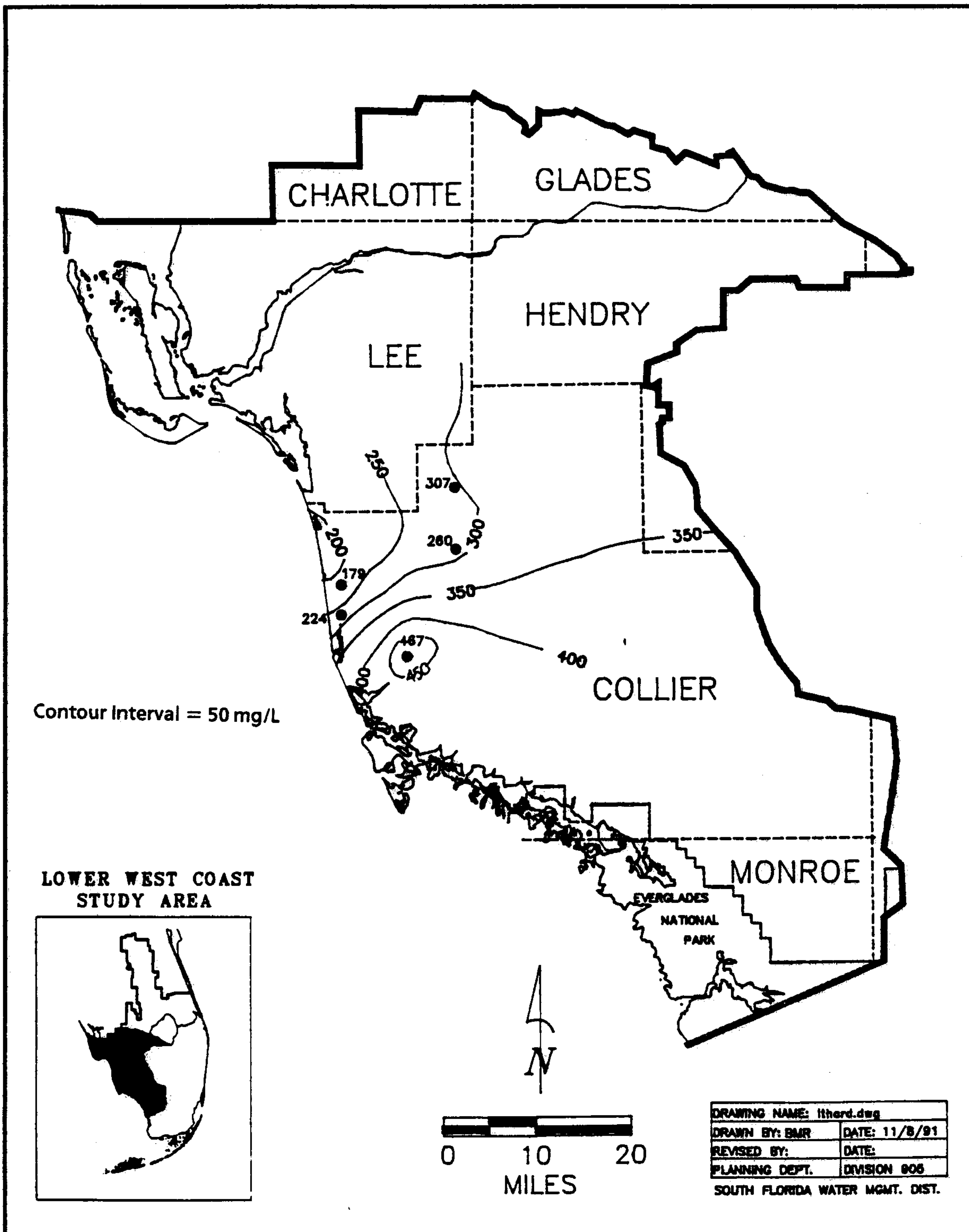

FIGURE H-23. Average Hardness (as mg/L of $CaCO_3$) of the Lower Tamiami Aquifer (1984 to 1990).

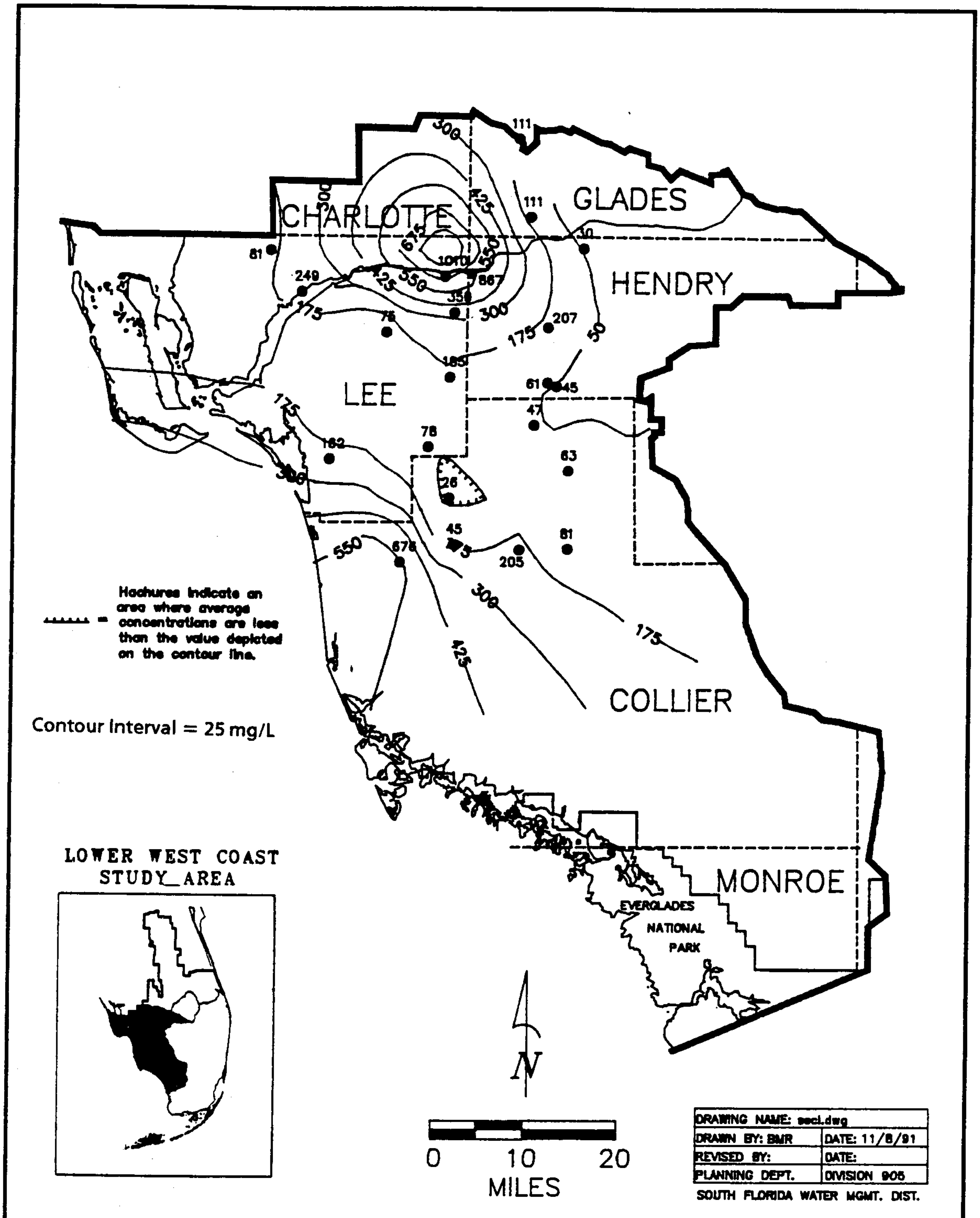

FIGURE H-24. Average Chloride Concentrations (mg/L) of the Sandstone Aquifer (1984 to 1990).

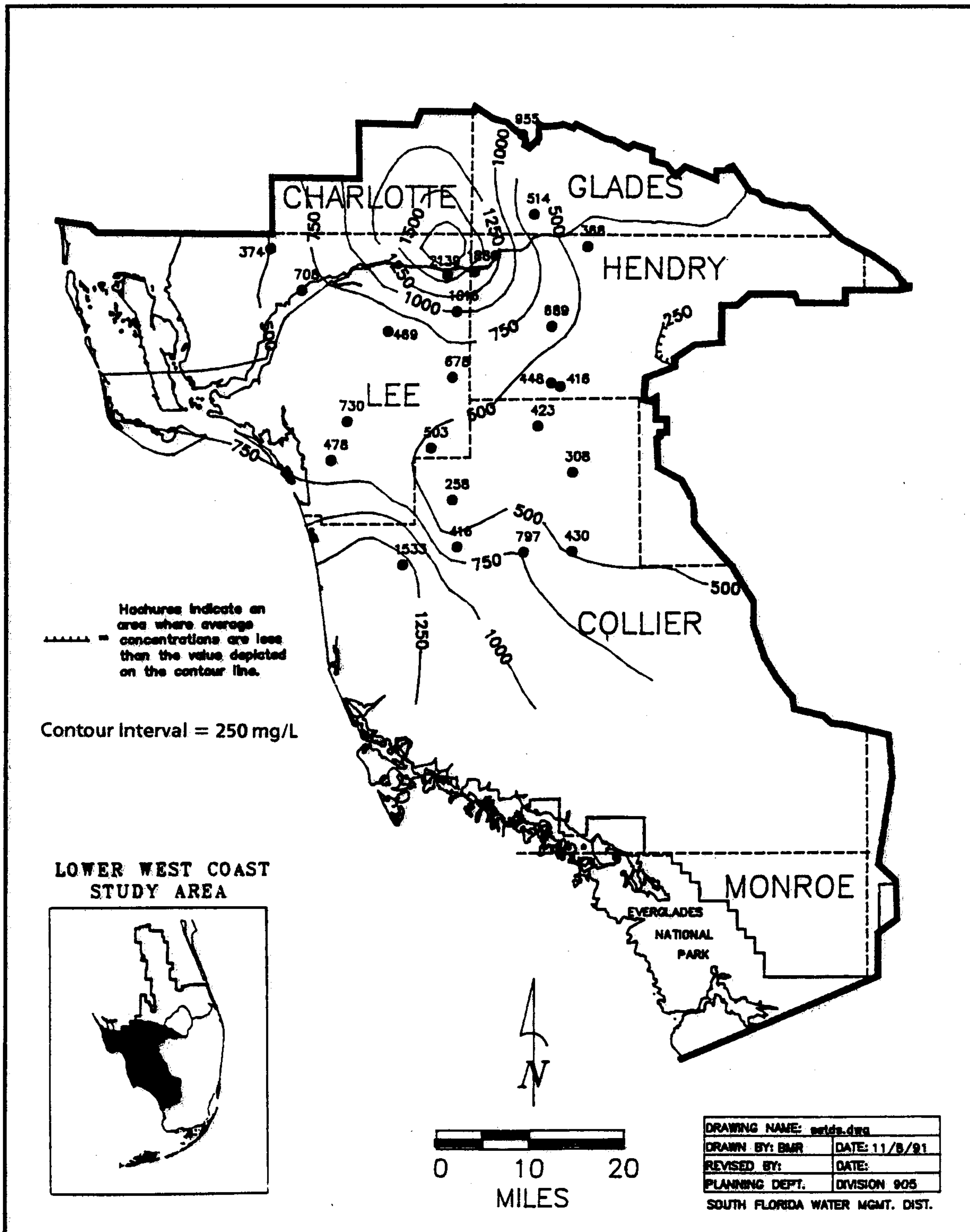

FIGURE H-25. Average Total Dissolved Solids (mg/L) of the Sandstone Aquifer (1984 to 1990).

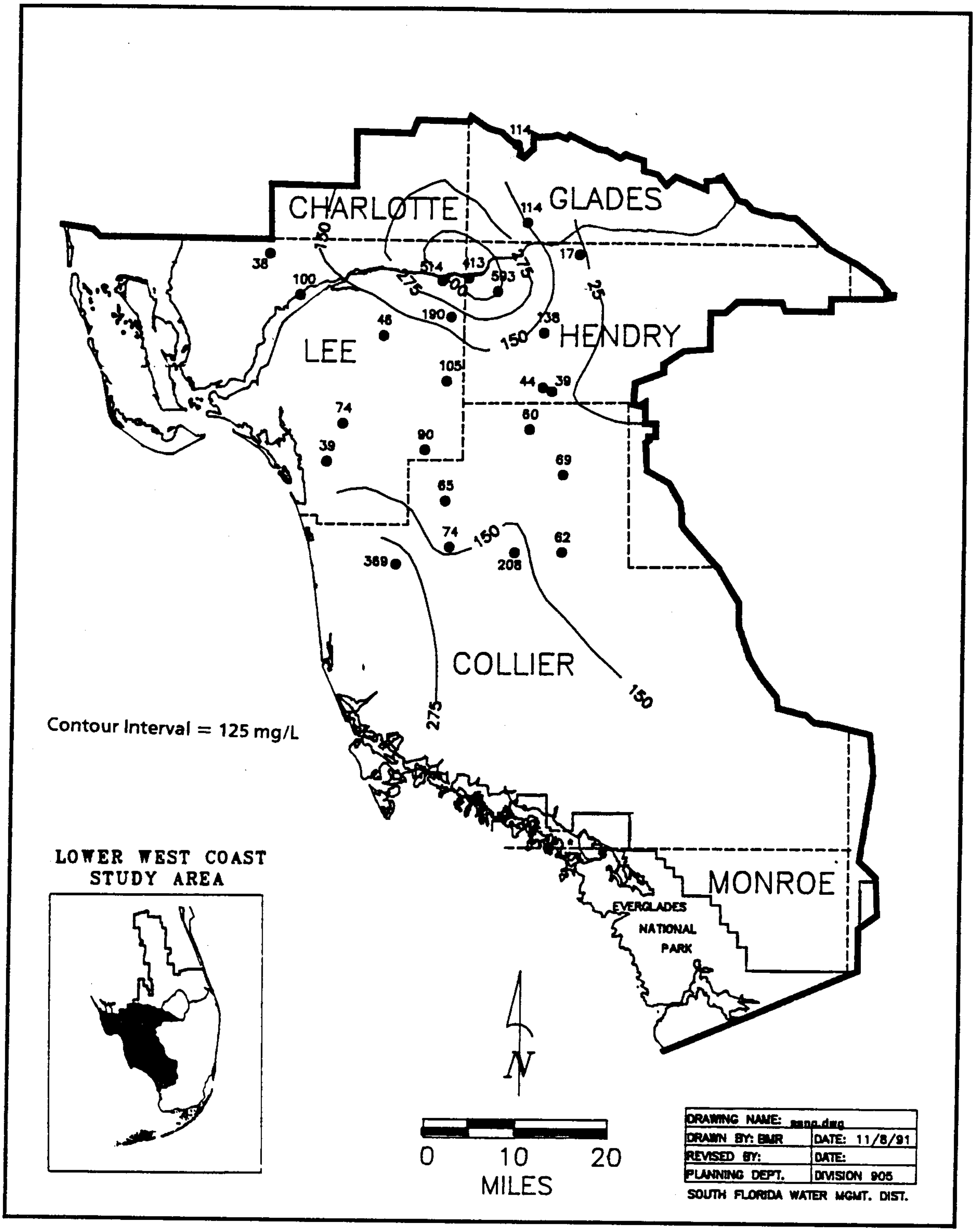

FIGURE H-26. Average Sodium Concentrations (mg/L) of the Sandstone Aquifer (1984 to 1990).

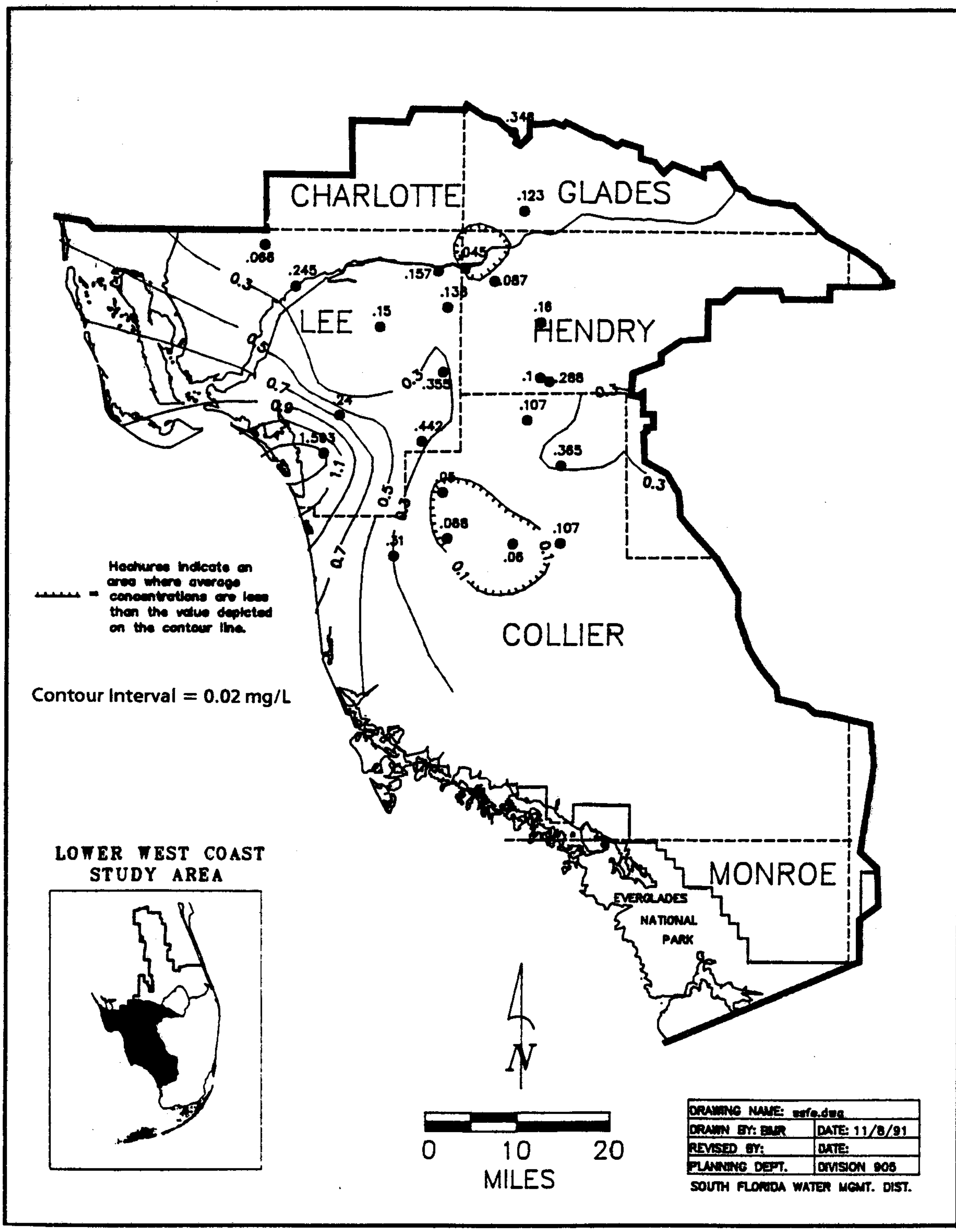

FIGURE H-27. Average Iron Concentrations (mg/L) of the Sandstone Aquifer (1984 to 1990).

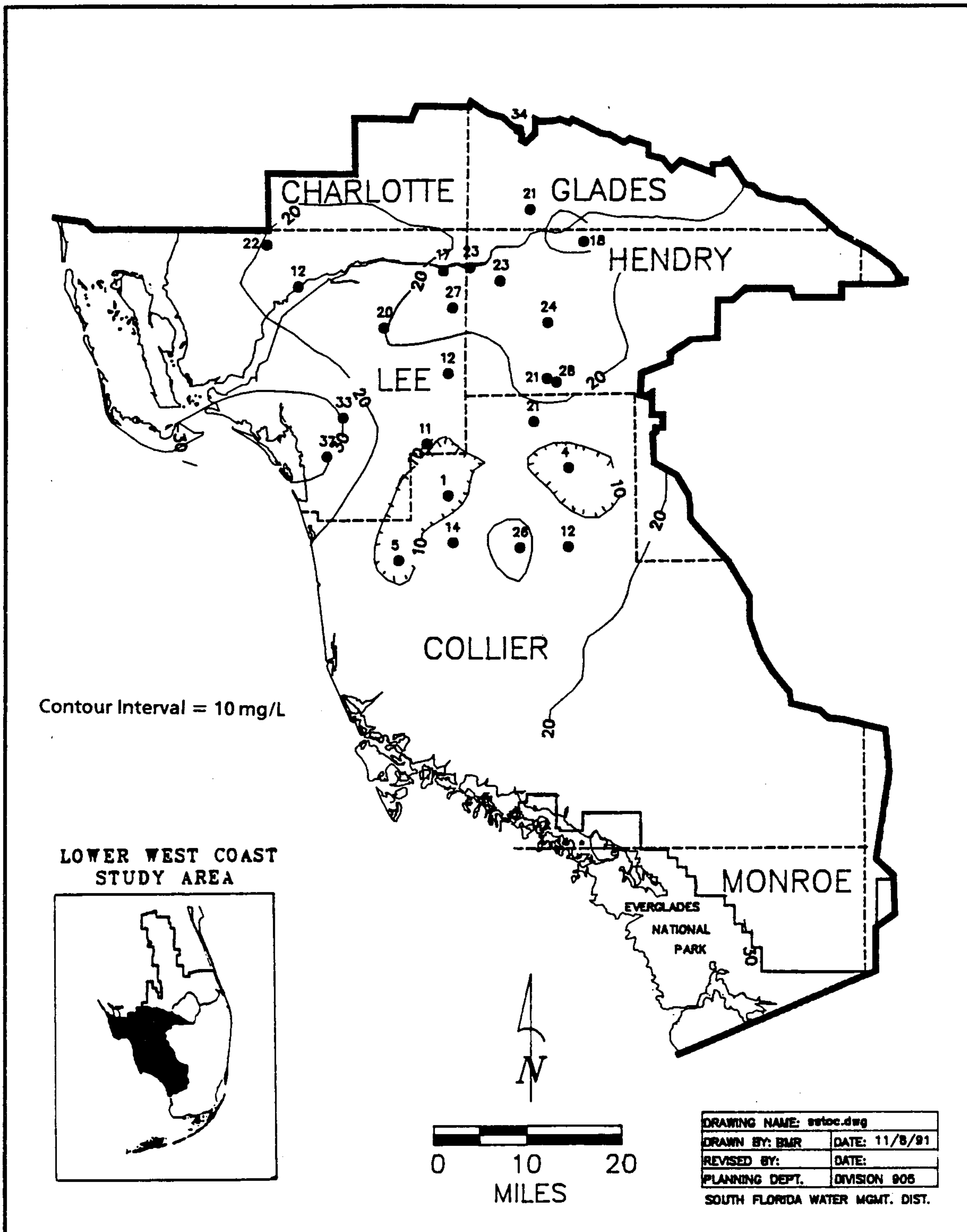

FIGURE H-28. Average Total Organic Carbon Concentrations (mg/L) of the Sandstone Aquifer (1984 to 1990).

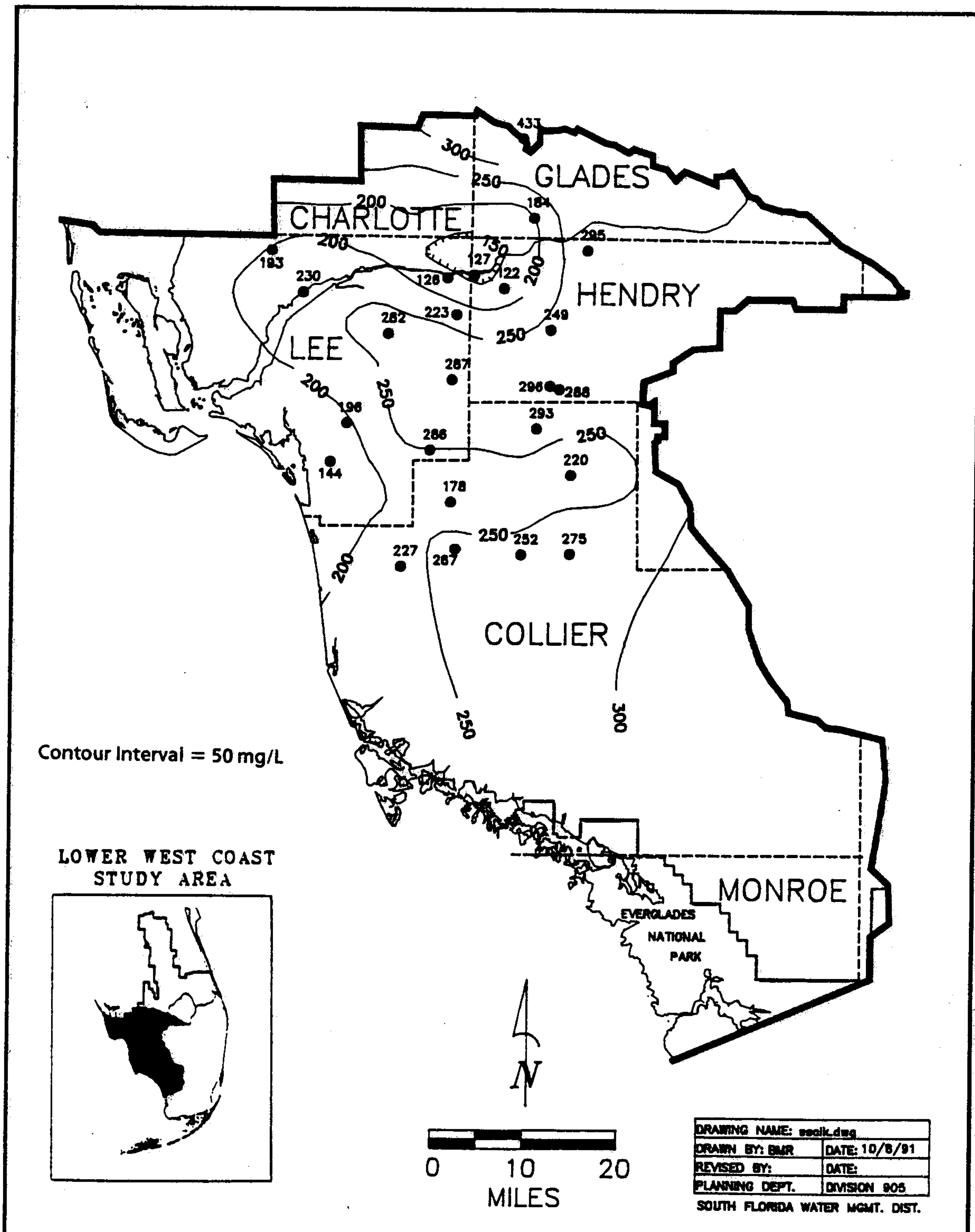

FIGURE H-29. Average Alkalinity (as mg/L of HCO_3) of the Sandstone Aquifer (1984 to 1990).

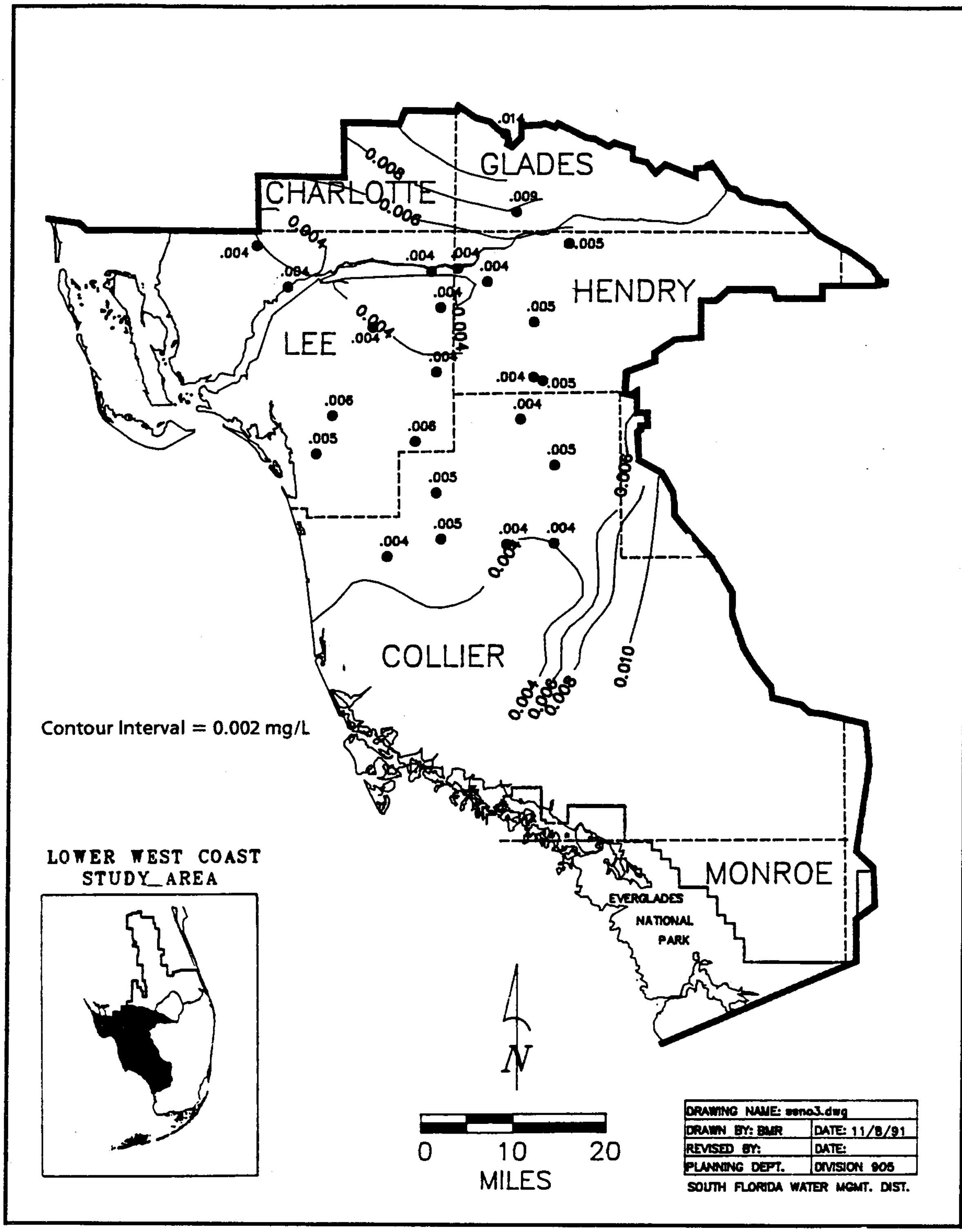

FIGURE H-30. Average Nitrate Nitrogen Concentrations (mg/L) of the Sandstone Aquifer (1984 to 1990).

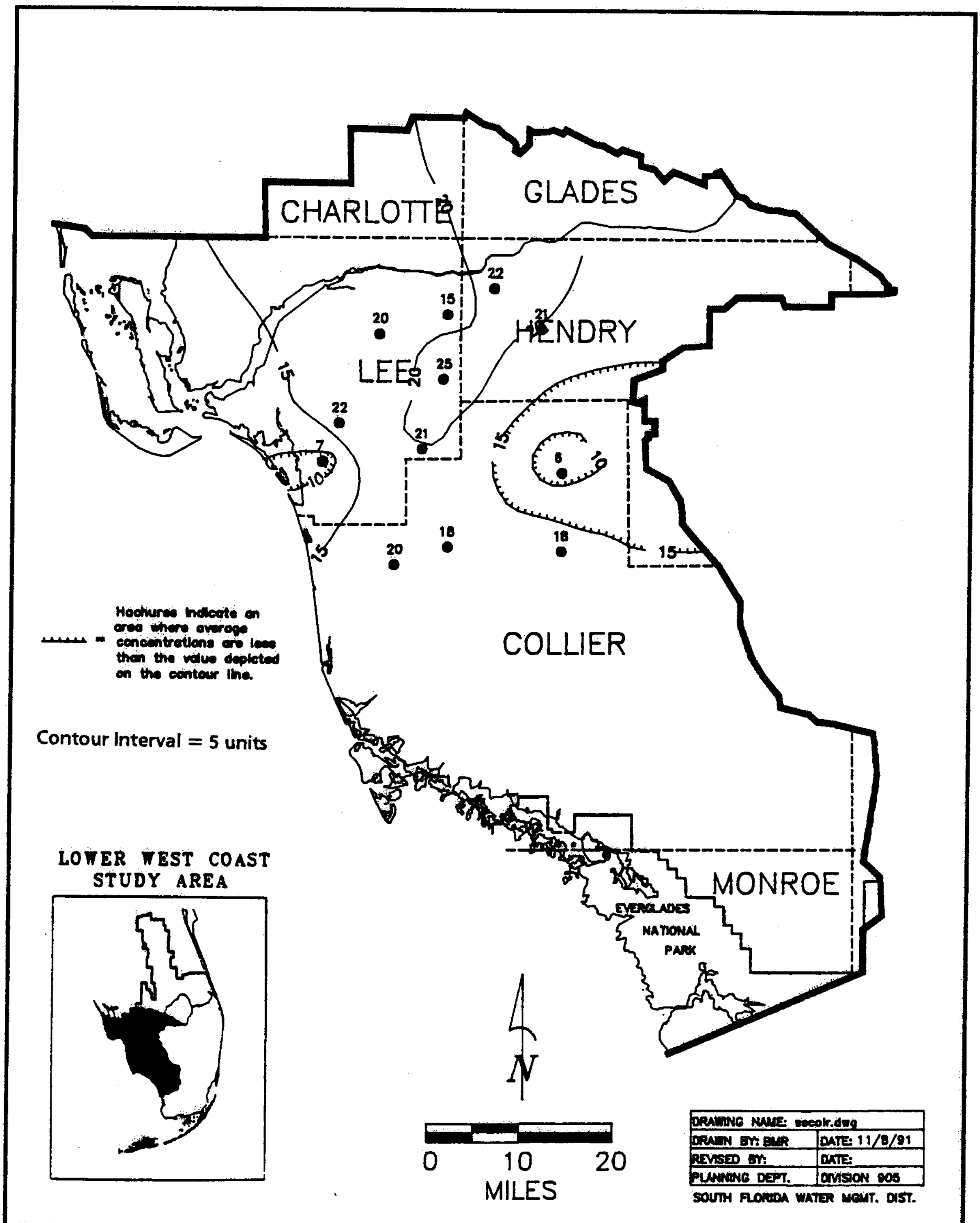

FIGURE H-31. Average Color (units) of the Sandstone Aquifer (1984 to 1990).

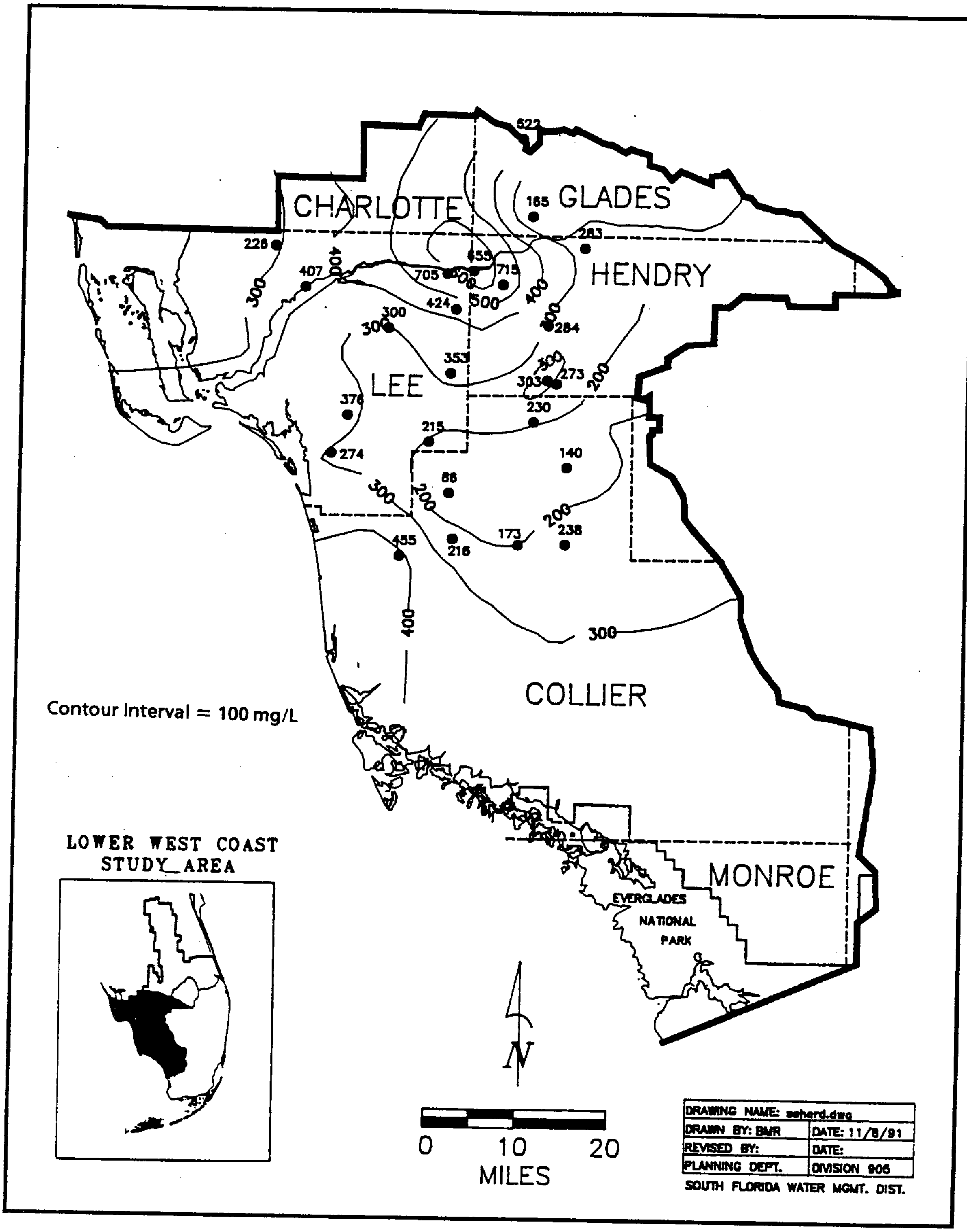

FIGURE H-32. Average Hardness (as mg/L of $CaCO_3$) of the Sandstone Aquifer (1984 to 1990).

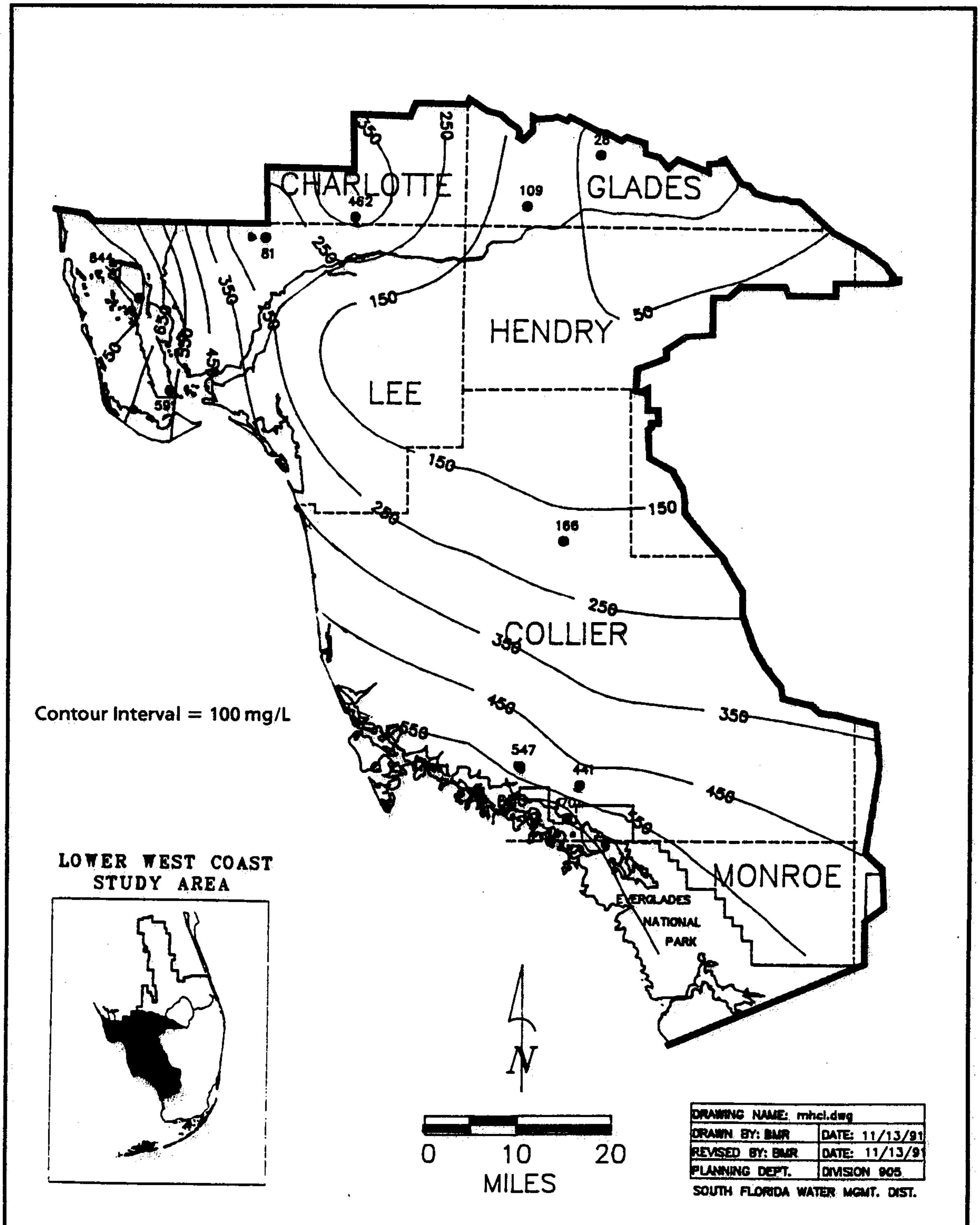

FIGURE H-33. Average Chloride Concentrations (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

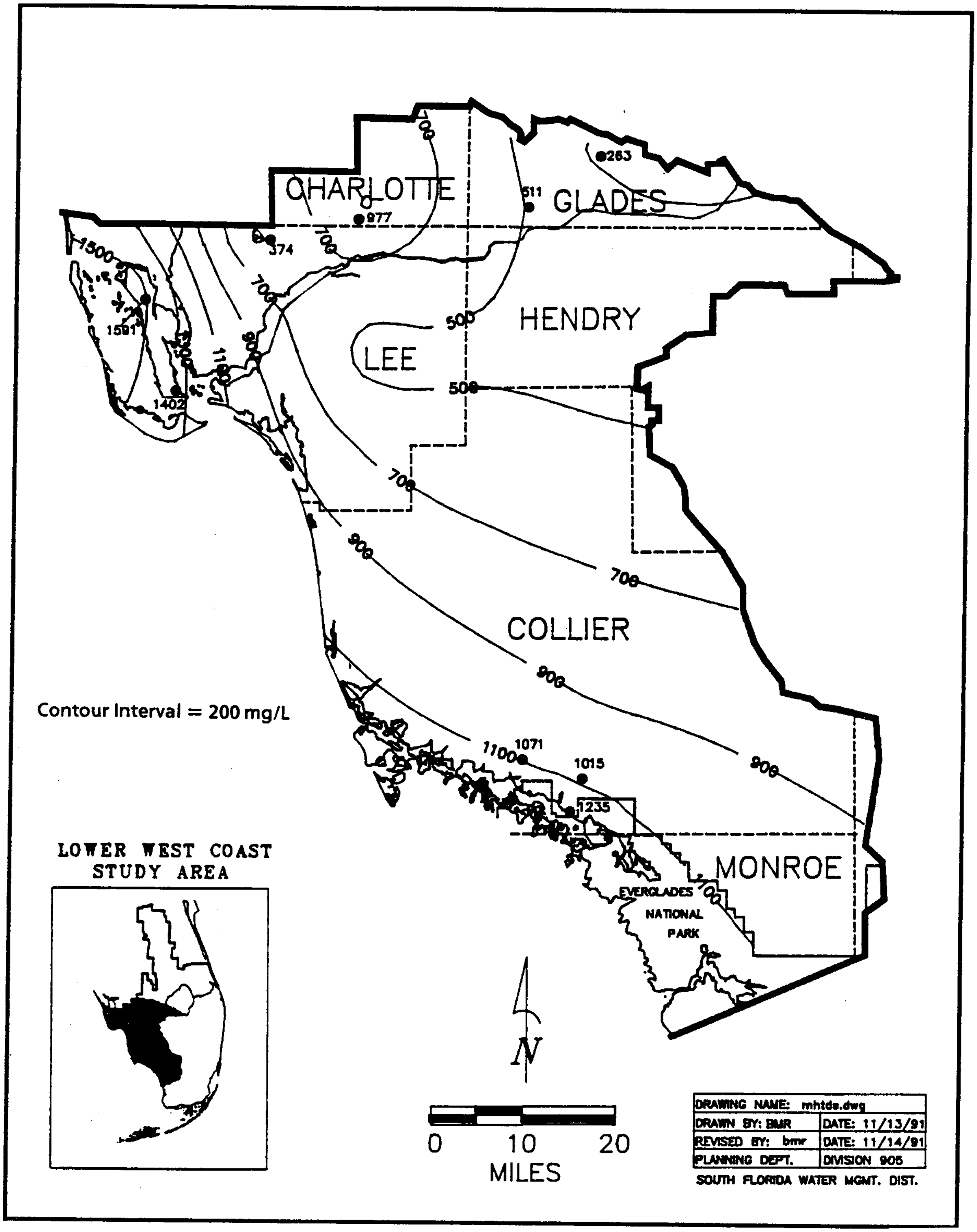

FIGURE H-34. Average Total Dissolved Solids (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

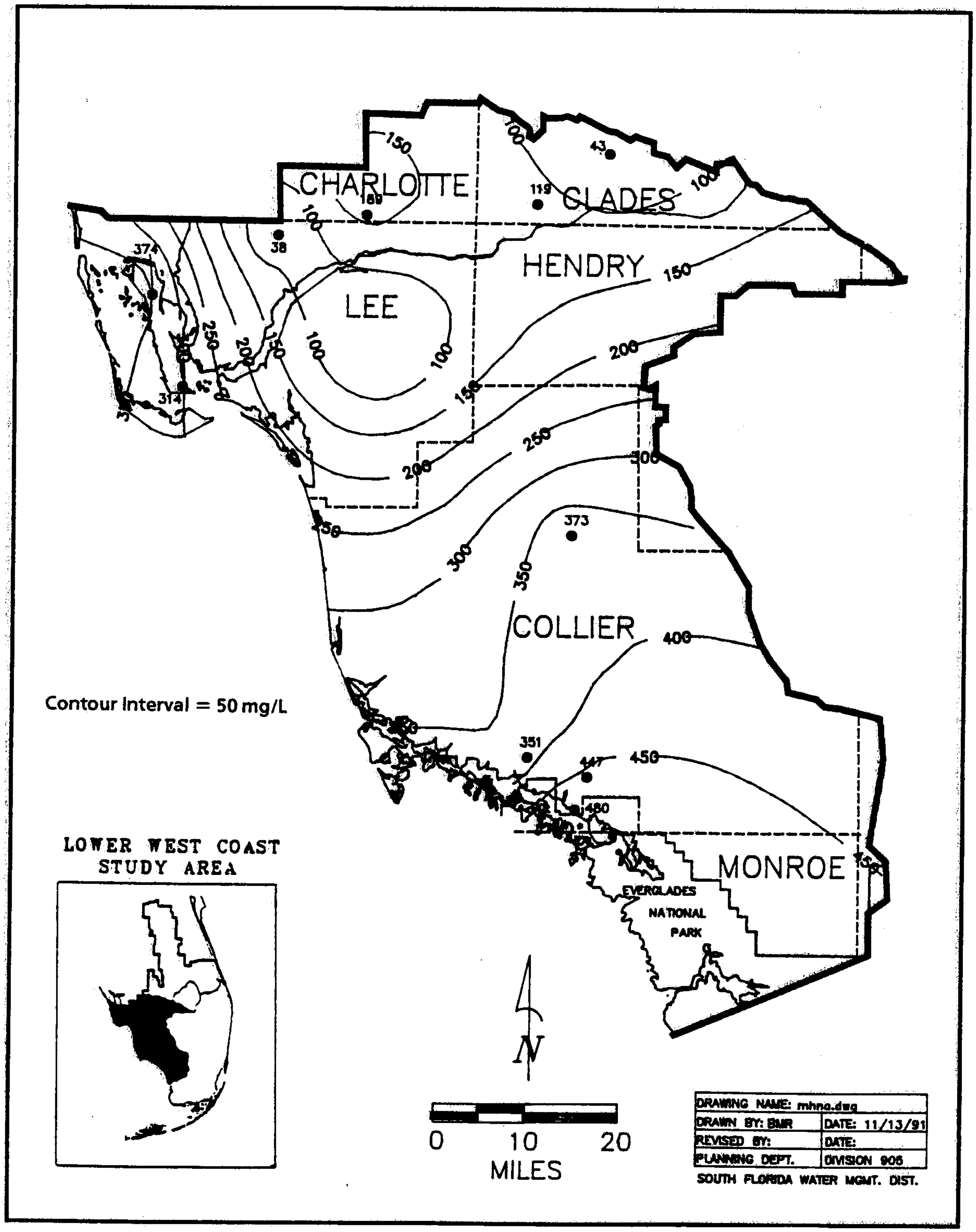

FIGURE H-35. Average Sodium Concentrations (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

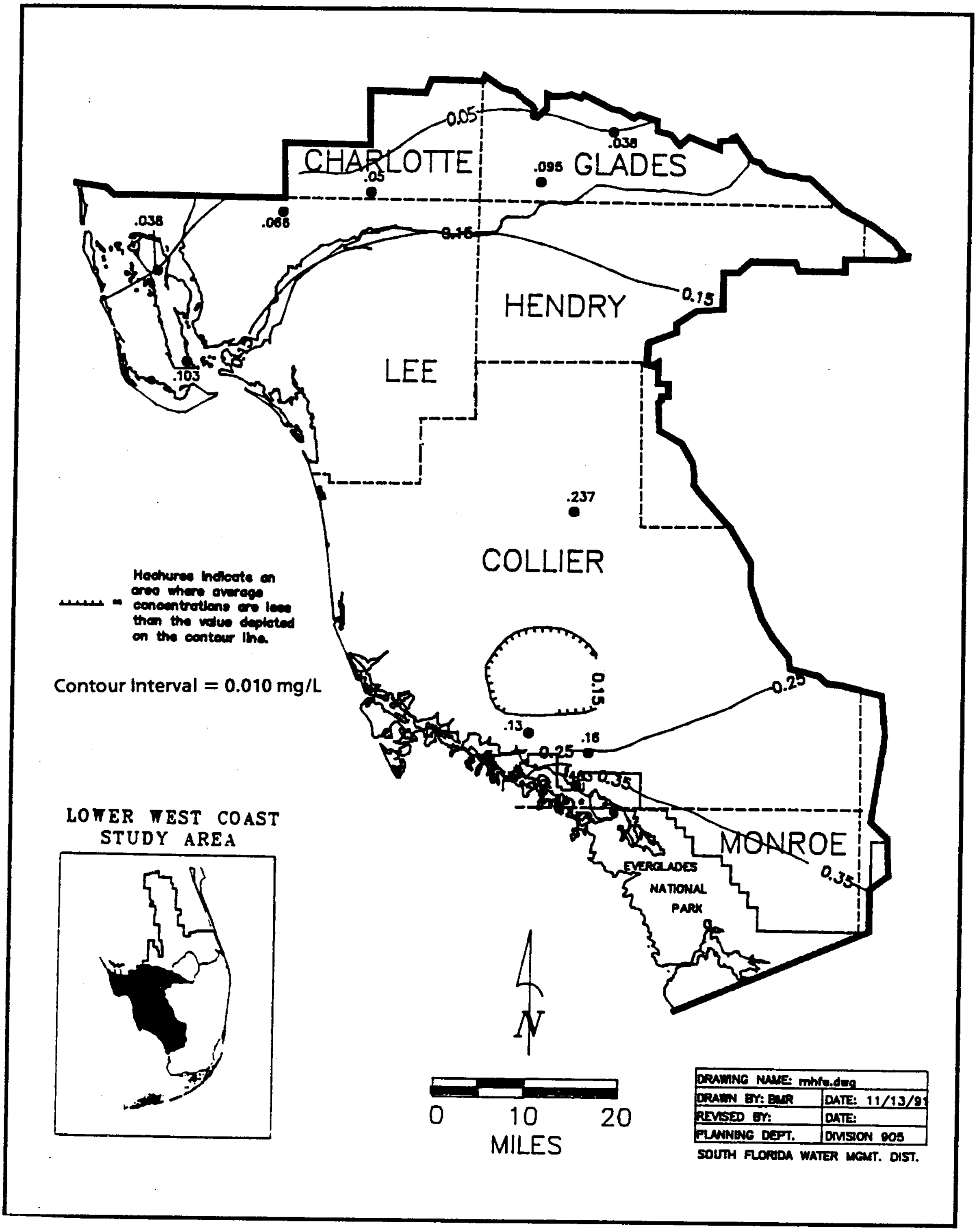

FIGURE H-36. Average Iron Concentrations (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

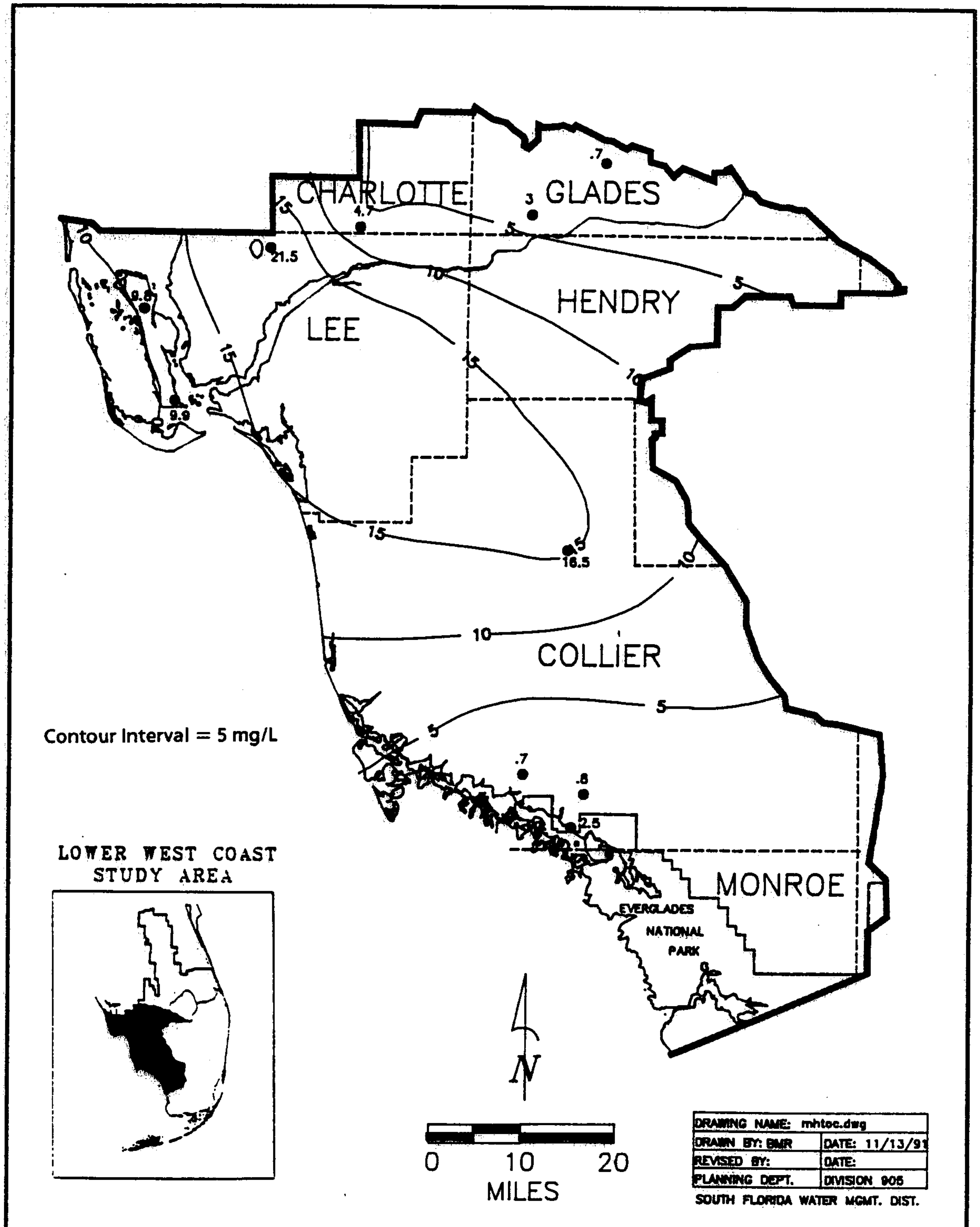

FIGURE H-37. Average Total Organic Carbon Concentrations (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

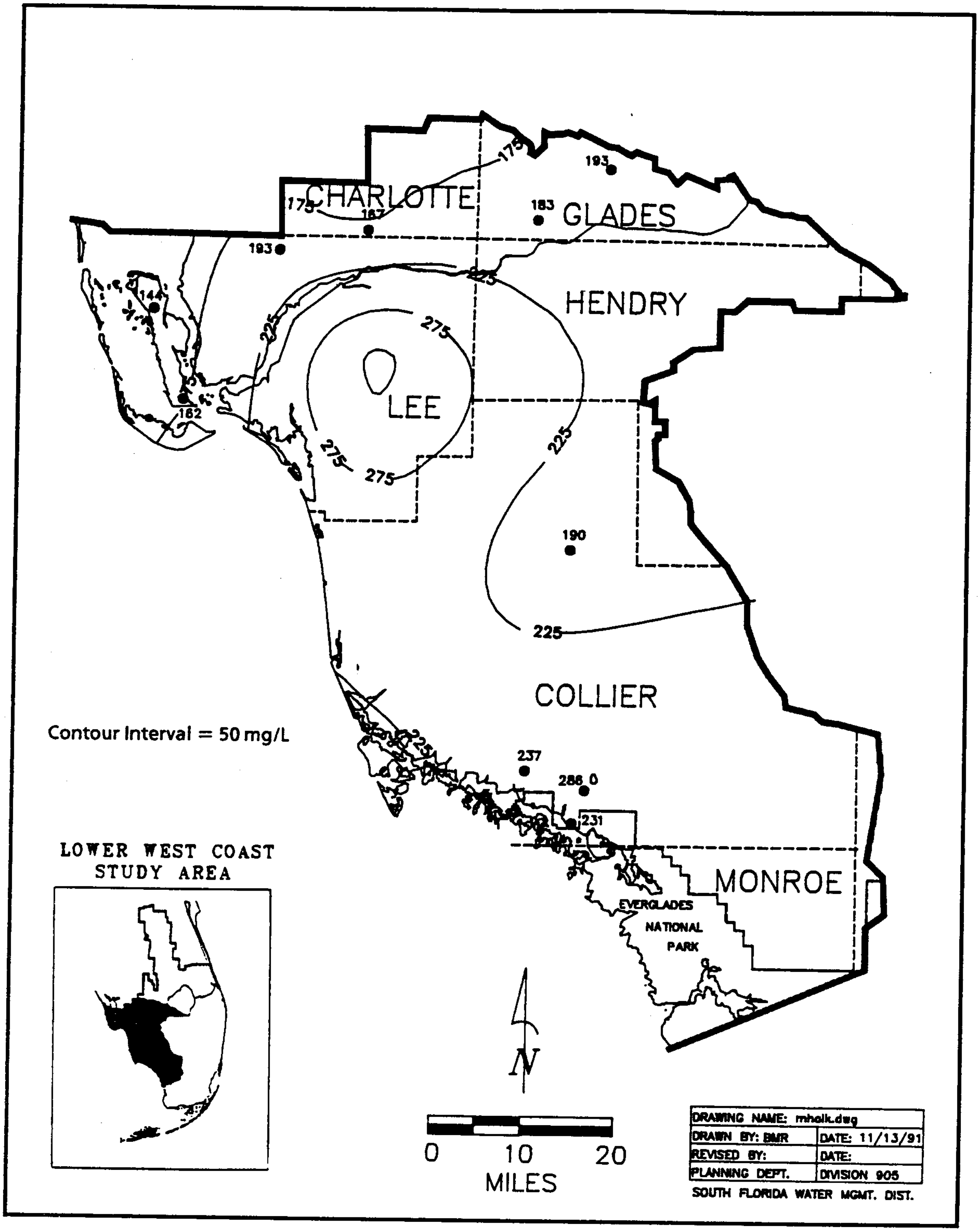

FIGURE H-38. Average Alkalinity (as mg/L of HCO_3) of the Mid-Hawthorn Aquifer (1984 to 1990).

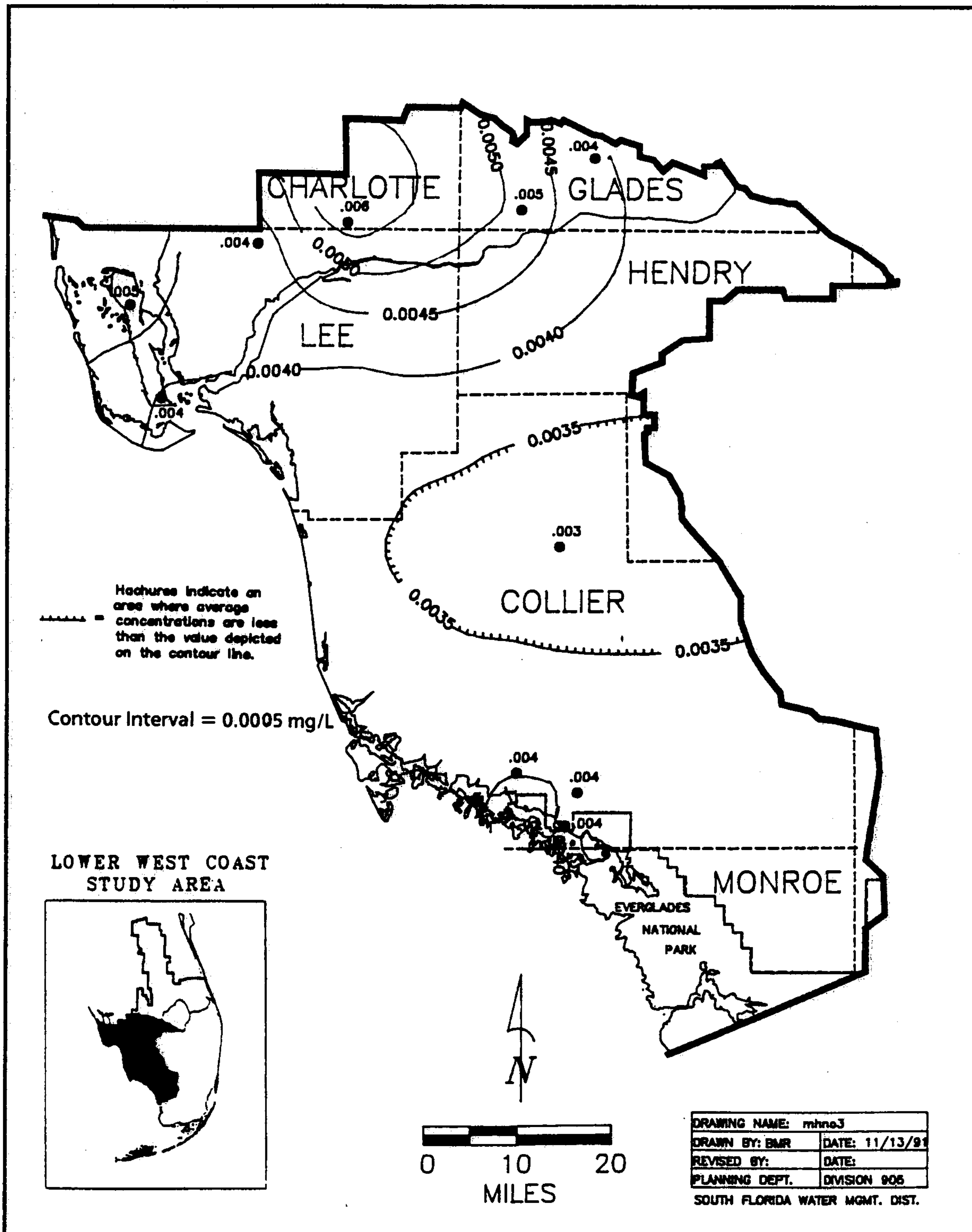

FIGURE H-39. Average Nitrate Nitrogen Concentrations (mg/L) of the Mid-Hawthorn Aquifer (1984 to 1990).

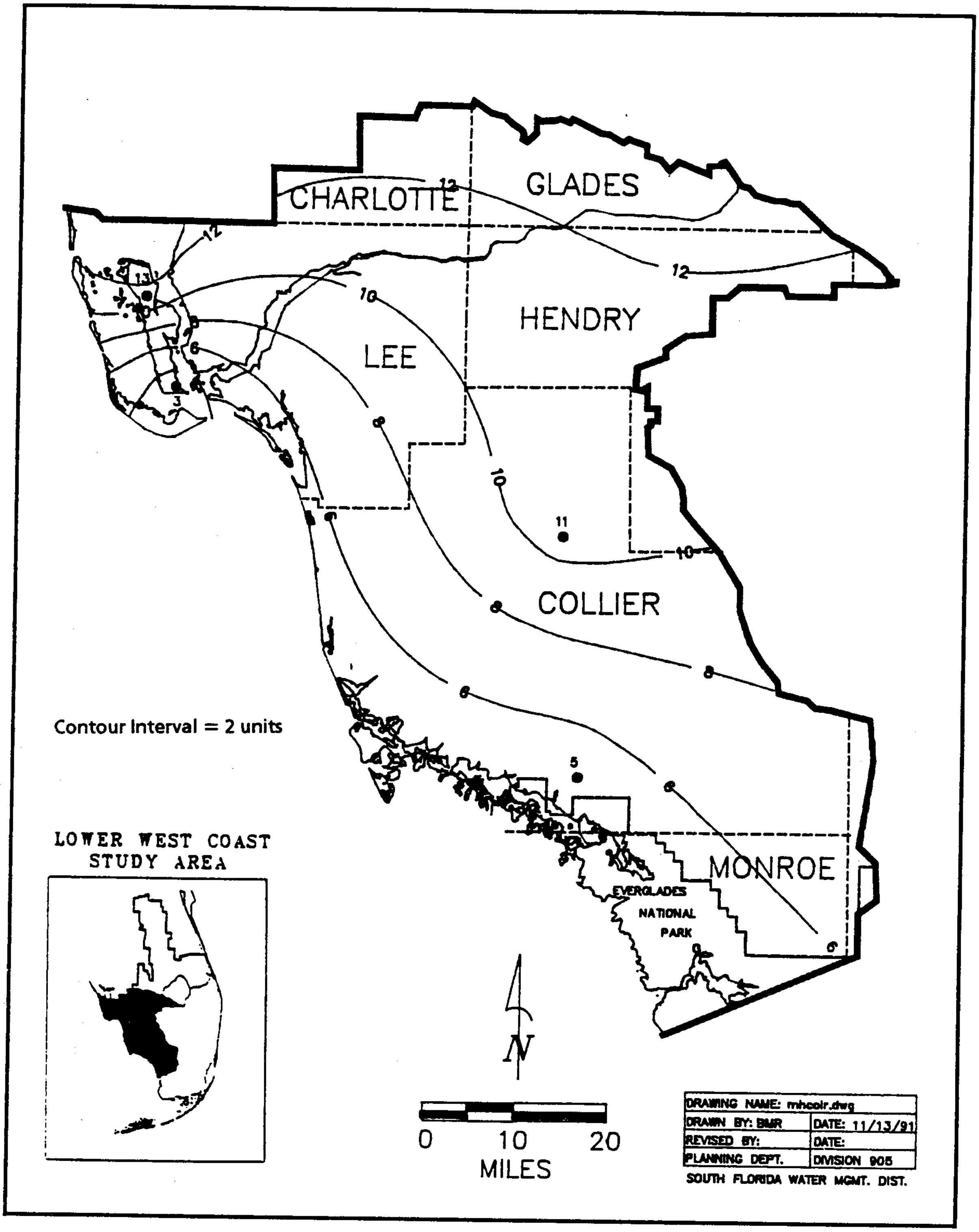

FIGURE H-40. Average Color (units) of the Mid-Hawthorn Aquifer (1984 to 1990).

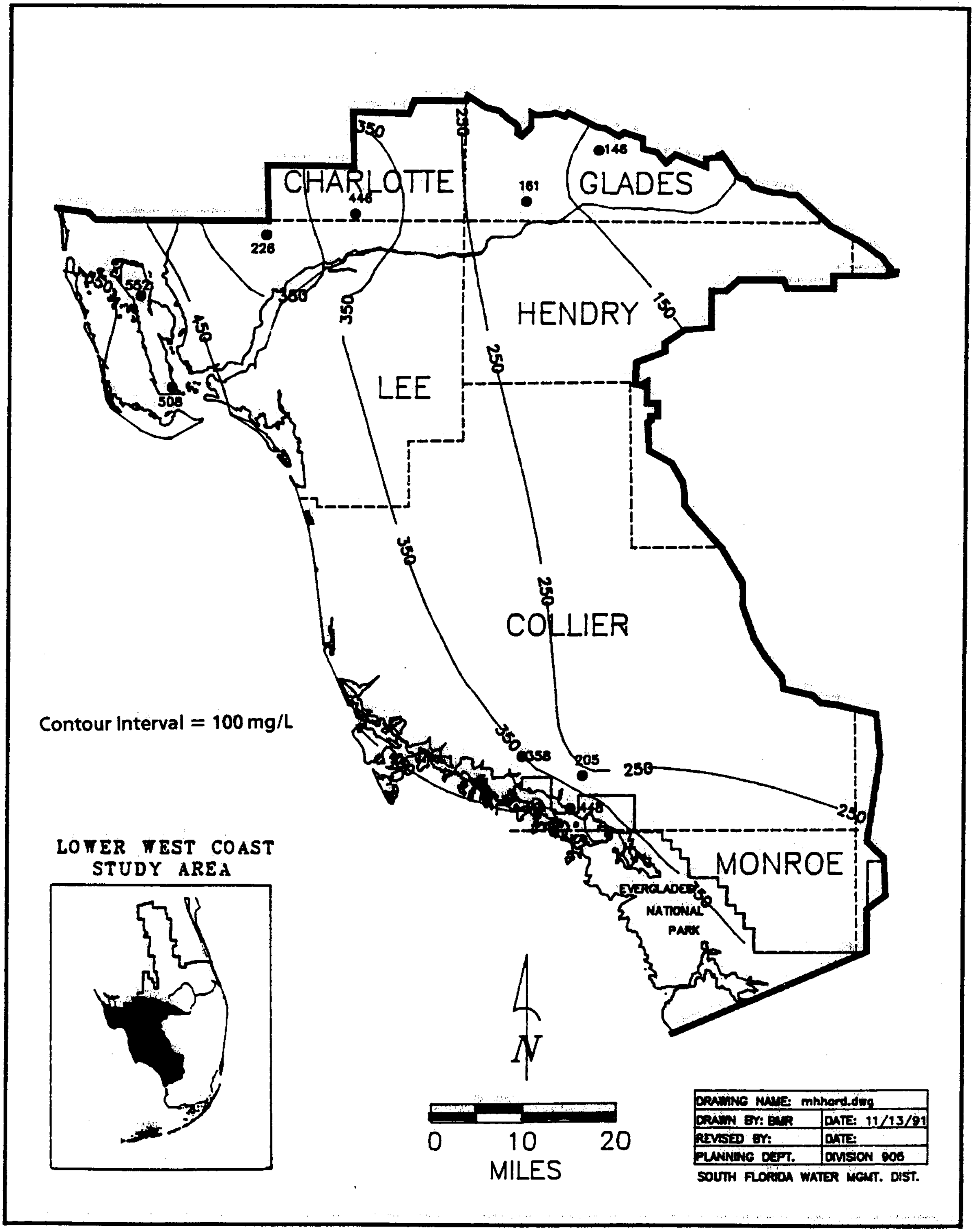

FIGURE H-41. Average Hardness (as mg/L of $CaCO_3$) of the Mid-Hawthorn Aquifer (1984 to 1990).

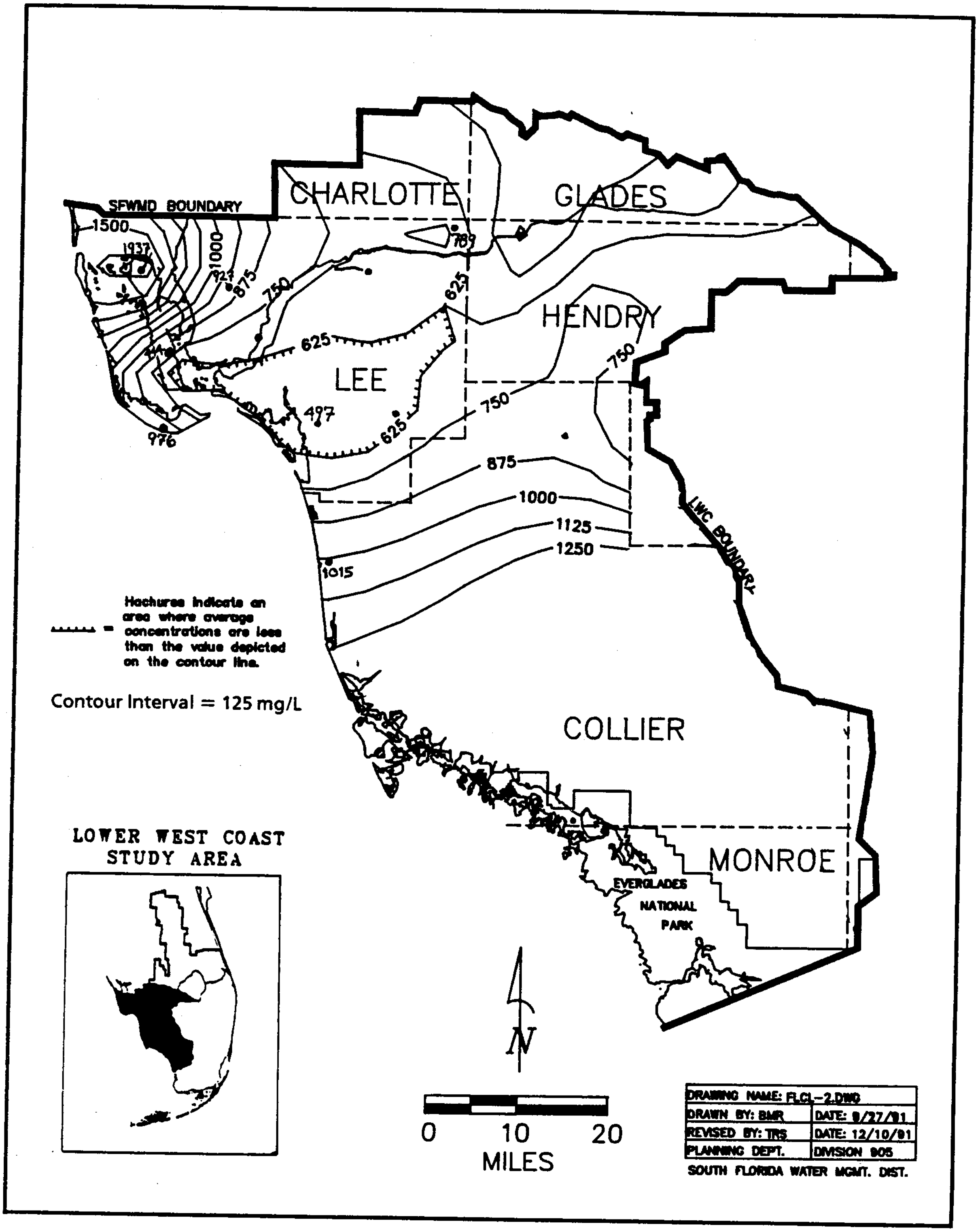

FIGURE H-42. Average Chloride Concentrations (mg/L) of the Lower Hawthorn Aquifer (1984 to 1990).

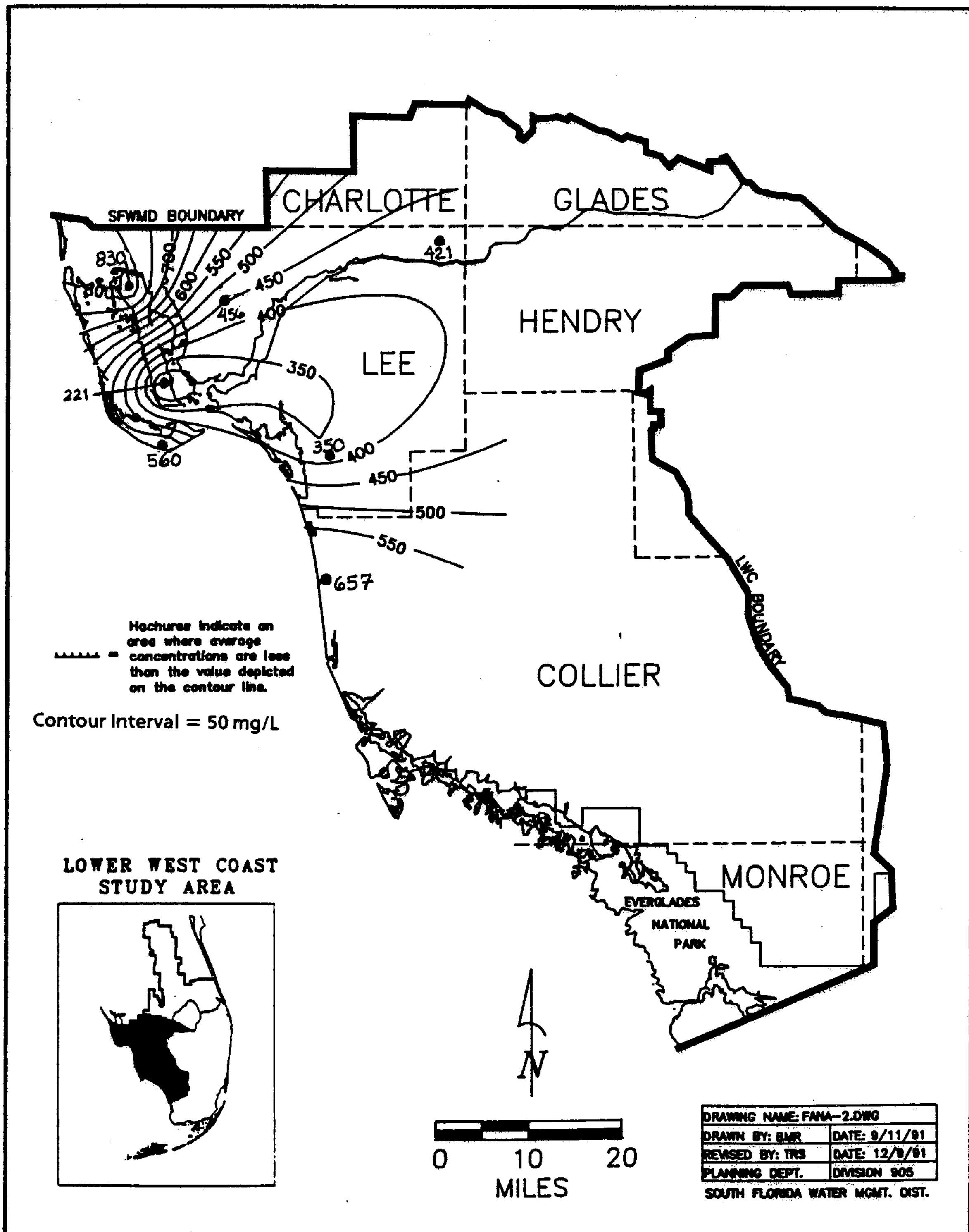

FIGURE H-43. Average Sodium Concentrations (mg/L) of the Lower Hawthorn Aquifer (1984 to 1990).

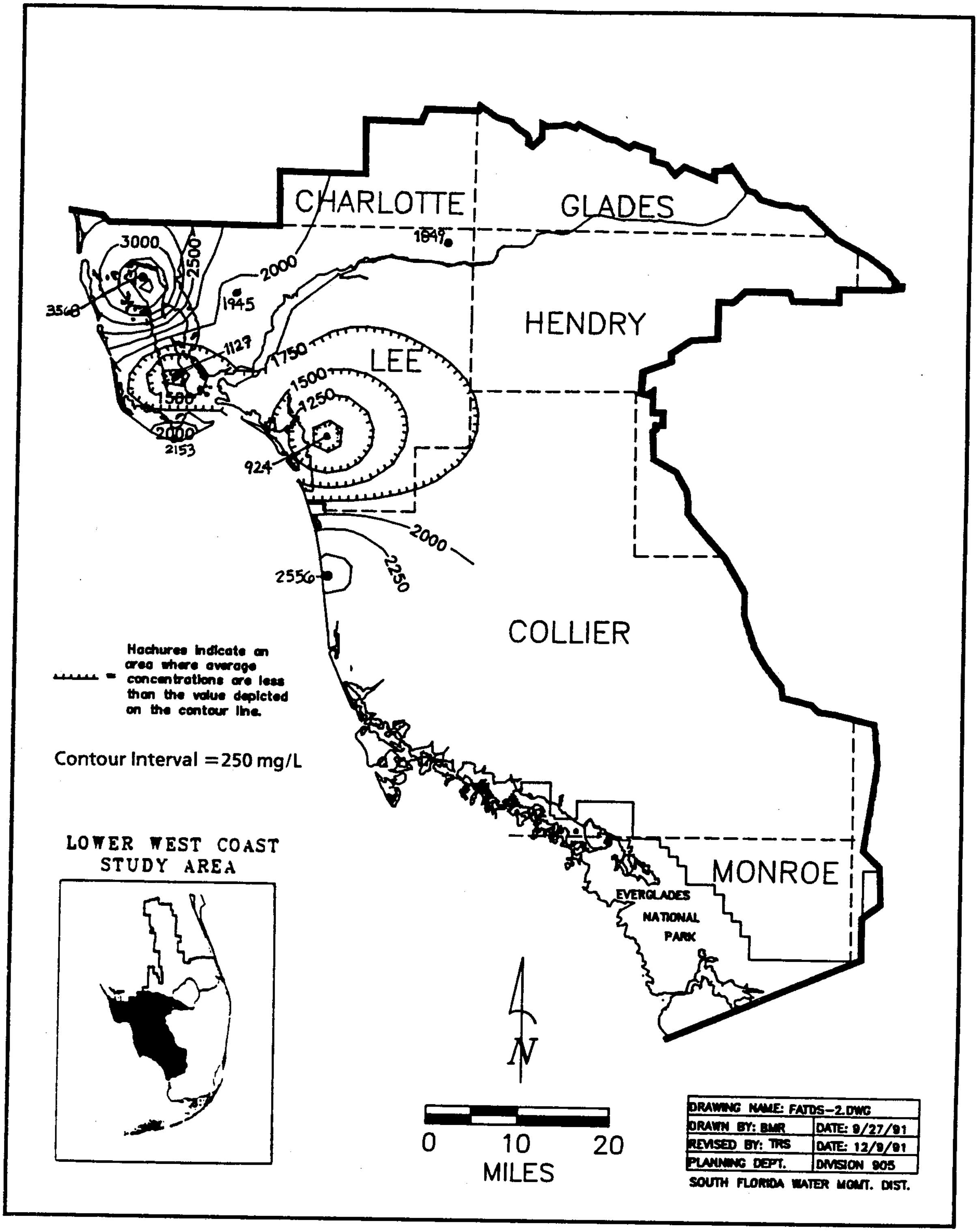

FIGURE H-44. Average Total Dissolved Solids (mg/L) of the Lower Hawthorn Aquifer (1984 to 1990).

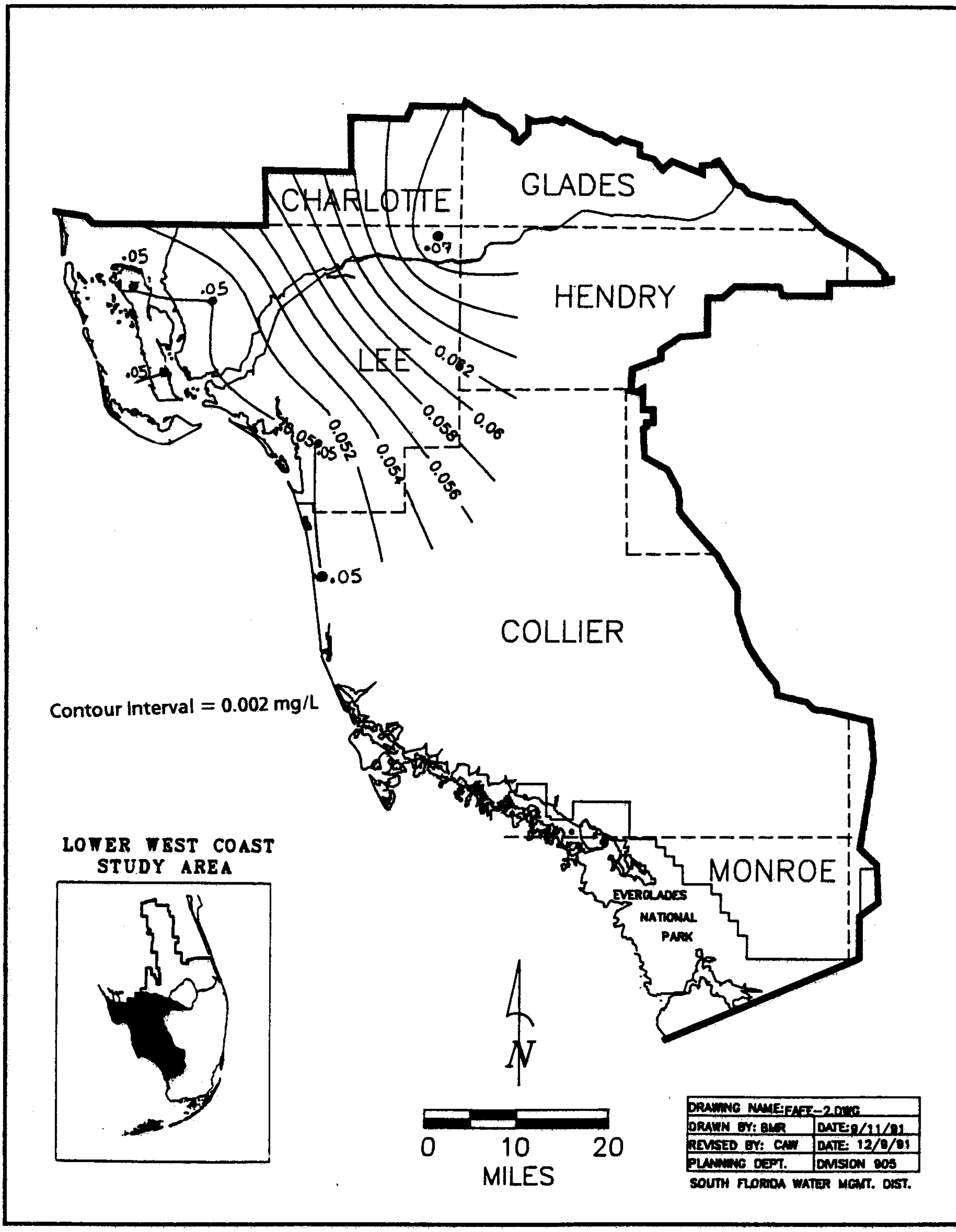

FIGURE H-45. Average Iron Concentrations (mg/L) of the Lower Hawthorn Aquifer (1984 to 1990).

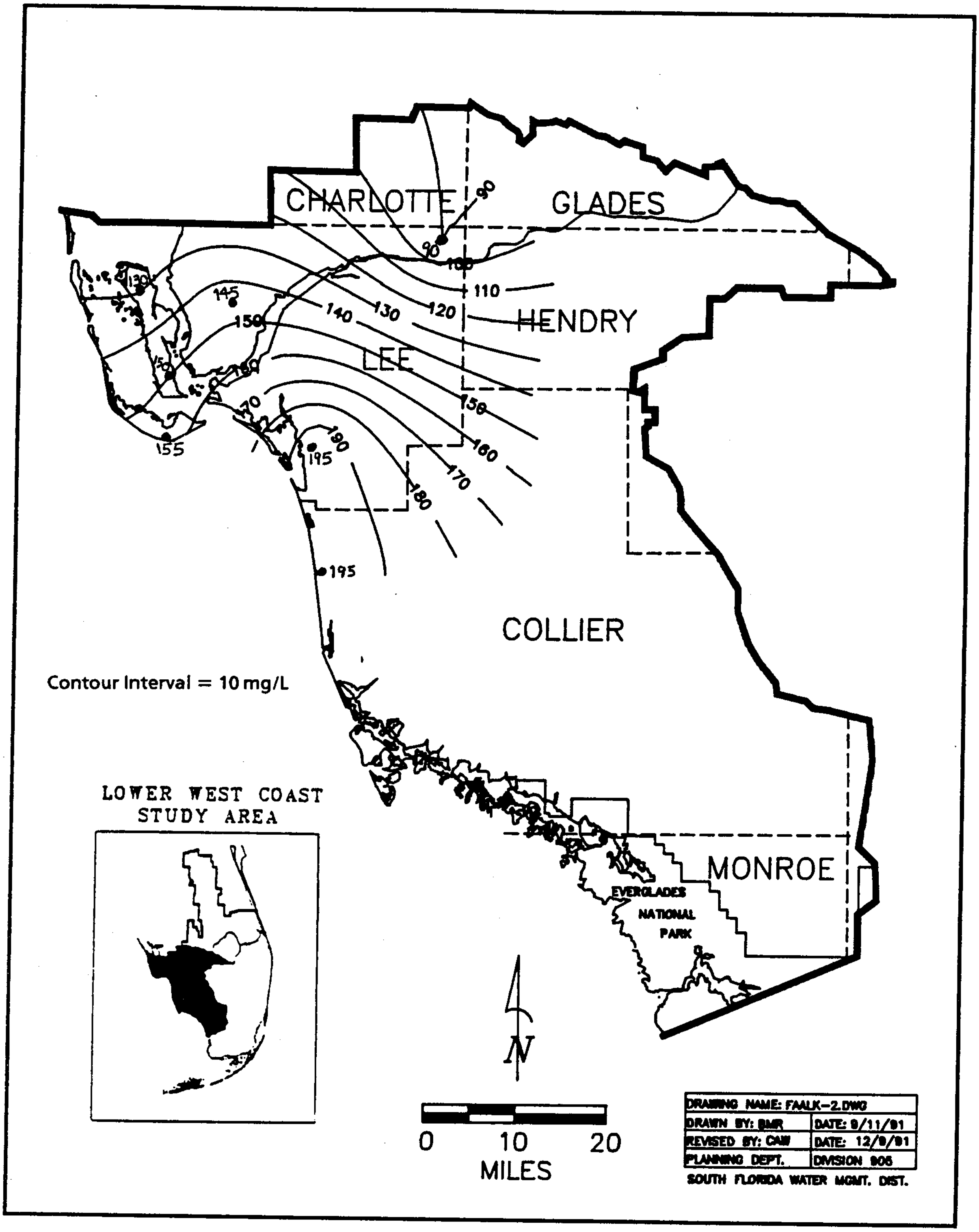

FIGURE H-46. Average Alkalinity (as mg/L of HCO3)of the Lower Hawthorn Aquifer (1984 to 1990).

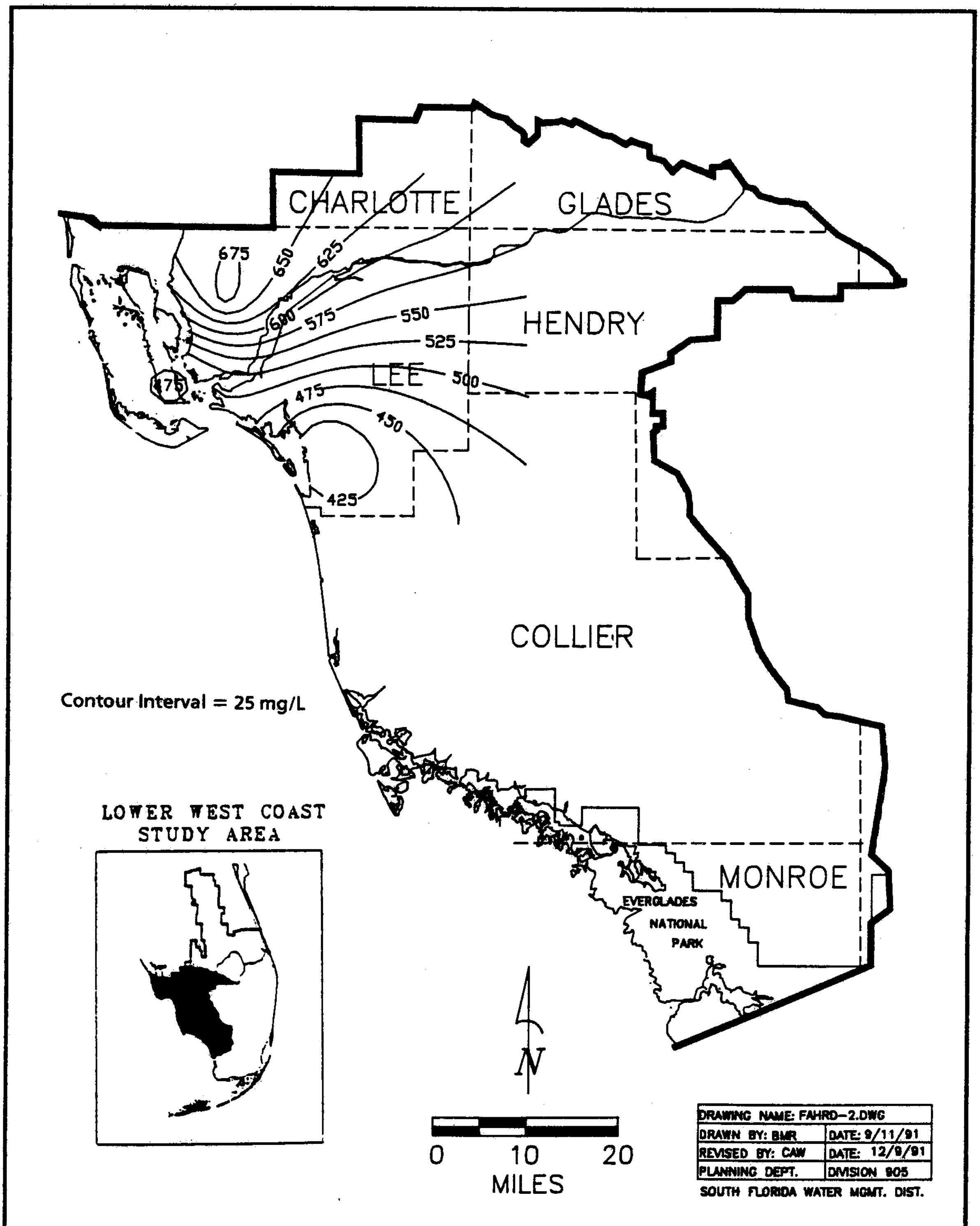

FIGURE H-47. Average Hardness (as mg/L of CaCO3) of the Lower Hawthorn Aquifer (1984 to 1990).

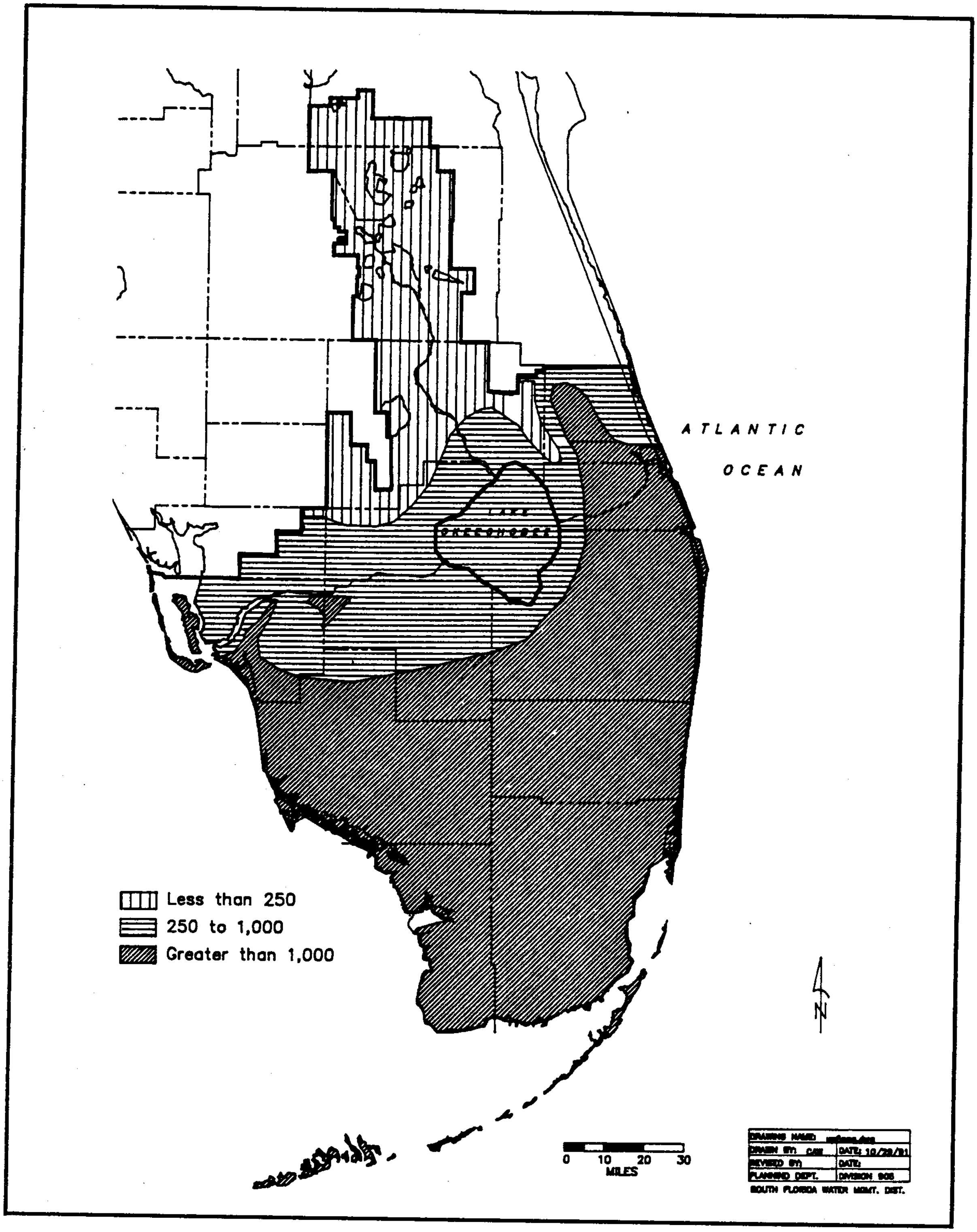

FIGURE H-48. Chloride Concentrations in the Upper 200 Feet of the Floridan Aquifer System (From Sprinkle, 1989).

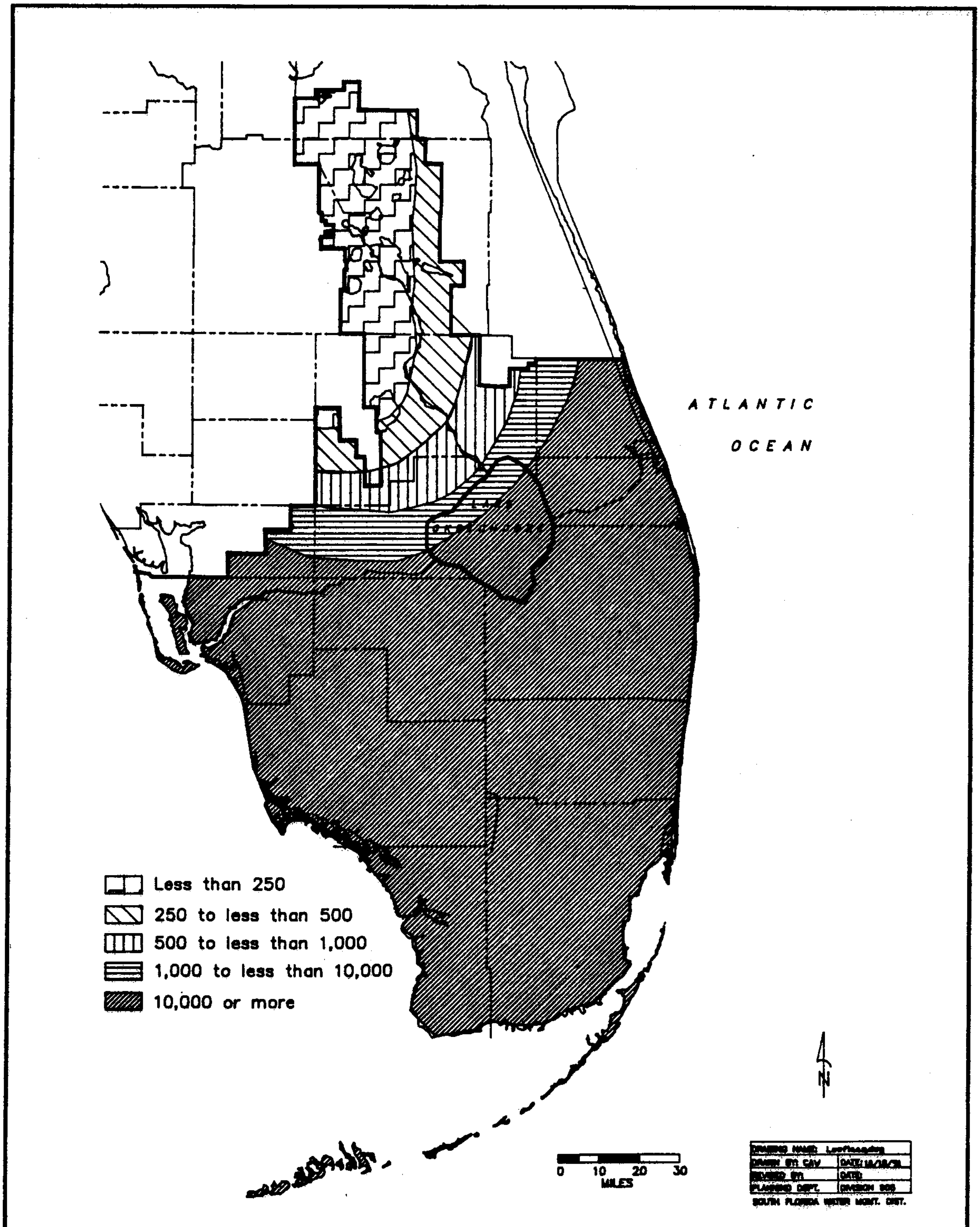

FIGURE H-49. Chloride Concentrations in the Lower Floridan Aquifer System (From Sprinkle, 1989).

CONTAMINATION SITES

Figures and other supporting documentation are provided for selected contamination sites in the LWC Planning Area is presented in this section. The contamination sites include landfills, Superfund sites, and FDER hazardous waste sites.

Landfills

Landfills are identified by the Florida Department of Environmental Regulation (FDER) as Class I, Class II or Class III facilities. Class I landfills are defined as those which receive an average of 20 tons or more of solid waste per day. Class II landfills are those that receive an average of less than 20 tons or 50 cubic yards of solid waste per day. Class III landfills are those that receive only trash or yard trash. The FDER has required all Class I and Class II landfills to have liners and leachate collection systems installed since 1985 (Chapter 17-701, F.A.C.).

In a sanitary landfill operation, a layer of compacted trash is covered with a layer of earth at least once a day. When the site is full, a thick layer of earth is placed on top to cap the landfill, and the land can be used for other purposes. This method of disposal carries with it an inherent potential for the pollution of ground water resources by the leachate created by landfill operations. Leachate is formed as liquids infiltrate through the solid waste and extract dissolved or suspended materials. If soil above and below a landfill is permeable, leachate can escape to contaminate proximal surface or ground water sources. This is especially a problem with older landfills that were constructed without impermeable liner systems.

There are 23 Class I and II landfills, as well as other unknown disposal sites, in the LWC Planning Area. These facilities, classified as either active, closed, or proposed, were compiled from several sources listed in Table H-6. The accompanying landfill location map is included as Figure H-50. Many of these sites had been used for years with little or no control over what materials were disposed of in them. Although most have not been active for some time, they may still represent a potential threat to the ground water resource.

A review of the ground water quality data from the active and closed landfills within the planning area indicates that immediately adjacent to and down gradient from the unlined fill areas, water quality is likely to be nutrient-rich, with elevated levels of ammonium and ammonia nitrogen, organic nitrogen, and total nitrogen. BOD, COD, sulfate, and total organic carbon were found to be elevated at most sites. Total dissolved solids commonly exceeds the 500 mg/L drinking water standard. Chloride, which is routinely used as an indicator parameter in tracking of leachate plumes, is usually elevated above normal background levels.

Several trace metals of significant concern were detected and include lead, detected at two landfill sites, and chromium, detected at three sites. Also elevated at nearly all the sites were iron and sodium. Iron levels may be very high, often present in concentrations which are many times the drinking water standard of 0.3 mg/L, although the regional ground water also contains natural levels of iron which frequently exceed this standard. Sodium, was elevated above background levels at many sites, and exceeded the drinking water standard of 160 mg/L in some cases.

Volatile organic compounds, synthetic organic compounds and pesticides were sampled for at several of the sites., and the following compounds have been detected, although in concentrations below FDER standards: 1,1,1 Trichloroethane was detected on one occasion. At another site, chlorobenzene and 1,2-dichlorobenzene were detected several times.

Not all landfills in the planning area exhibited poor ground water quality. Data from some sites appeared to reflect normal background ground water quality. Size and age of the landfill, types of wastes produced in the area, local hydrogeology and landfilling techniques are factors which can dictate the extent and character of the resulting impacts on ground water quality. In addition, an effective ground water monitoring program is crucial for accurate determination of ground water degradation. Improperly located Monitor wells can result in the oversight of a contaminant plume.

TABLE H-6. Class I and II Landfill Facilities in Lower West Coast Planning Area.

Map Number	Facility Name	Class	Status	Source
Collier County				
1	Goodlette Road	--	Closed	6
2	Immokalee #1	I	Closed	1,3,4,6
3	Immokalee #2	I	Active	1,3,4,5,6
4	Naples	I	Active	1,3,4,5,6
5	Naples Airport	I	Closed	3,4,5,6
6	Temple Drive	--	Closed	6
Glades County				
7	Glades County #2	I	Active	4
Hendry County				
8	Airglades	I	Closed	1,6
9	County Landfill (Pioneer)	I	Active	1,4,5,6
10	Labelle	I	Closed	6
11	Lee/Hendry	I	Proposed	5
Lee County				
12	Alva School Dump	--	Closed	6
13	Alva-Spanish River Dump	--	Closed	6
14	Billy's Creek Dump	--	Closed	6
15	Buckingham	I	Closed	2,4,5,6
16	Corkscrew Road	II	Closed	4
17	Detar Lane	II	Closed	4
18	Fort Myers, City	--	Closed	2,6
19	Gulf Coast	I	Active	1,2,4,5,6
20	Harlem Heights (Kelly Road)	II	Closed	2,4,5,6
21	Lake Kennedy	II	Closed	4
22	Old Lehigh Dump	I	Closed	6
23	Pine Island Dump	--	Closed	6

Source Codes:
1- Miller *et al.* (1987).
2- Phone conversation January 3, 1991 with Mr. Van Horn, Lee County Solid Waste, Fort Myers, FL.
3- Letter dated December 31, 1990 from Robert Fahey, Solid Waste Management Director, Collier County Government, Naples, FL.
4- Letter dated January 17, 1991 from Philip Edwards, FDER South District Deputy Assistant Secretary, Fort Myers, FL.
5- South Florida Water Management District. 1989. Solid Waste Disposal Site Surface Water Management System Inventory. SFWMD, West Palm Beach, FL.
6- Shaw, J.E. 1985. Water Quality Assurance Act Program Progress Report December 1983 to March 1985. SFWMD, West Palm Beach, FL.

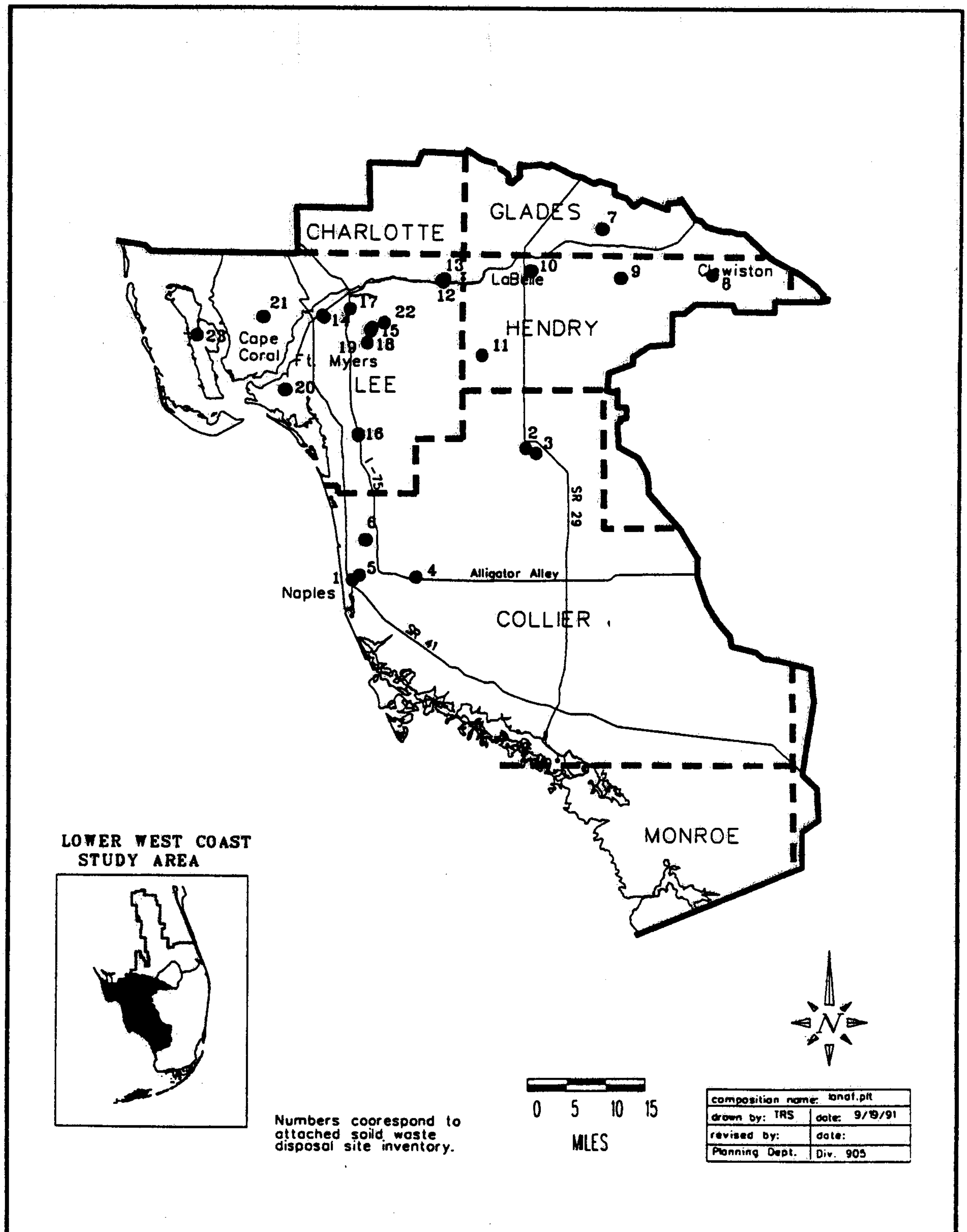

FIGURE H-50. Location of Landfills in the Lower West Coast Planning Area.

Superfund Program Sites

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as the Superfund, requires the U.S. Environmental Protection Agency (U.S. EPA) to maintain a national hazardous waste site inventory, also known as the Superfund inventory or CERCLIS (U.S. EPA,1990). The inventory consists of sites that are either actual or potential threats of hazardous waste substance releases to the environment. Sites considered to have a high health and environmental risk are included in EPA's National Priorities List (NPL). There are more than 32,000 sites in the Superfund inventory of which 1,236 sites are on the NPL. Once a site is listed in the Superfund inventory, the site will remain on the list for record keeping purposes even after the site has been cleaned up and no further action is needed.

The Superfund inventory contains 27 sites located in the LWC Planning Area (U.S. EPA, 1990). The location of these sites are identified in Figure H-51. Florida has 54 sites on the NPL of which none exist in the LWC Planning Area (FDER, 1990).

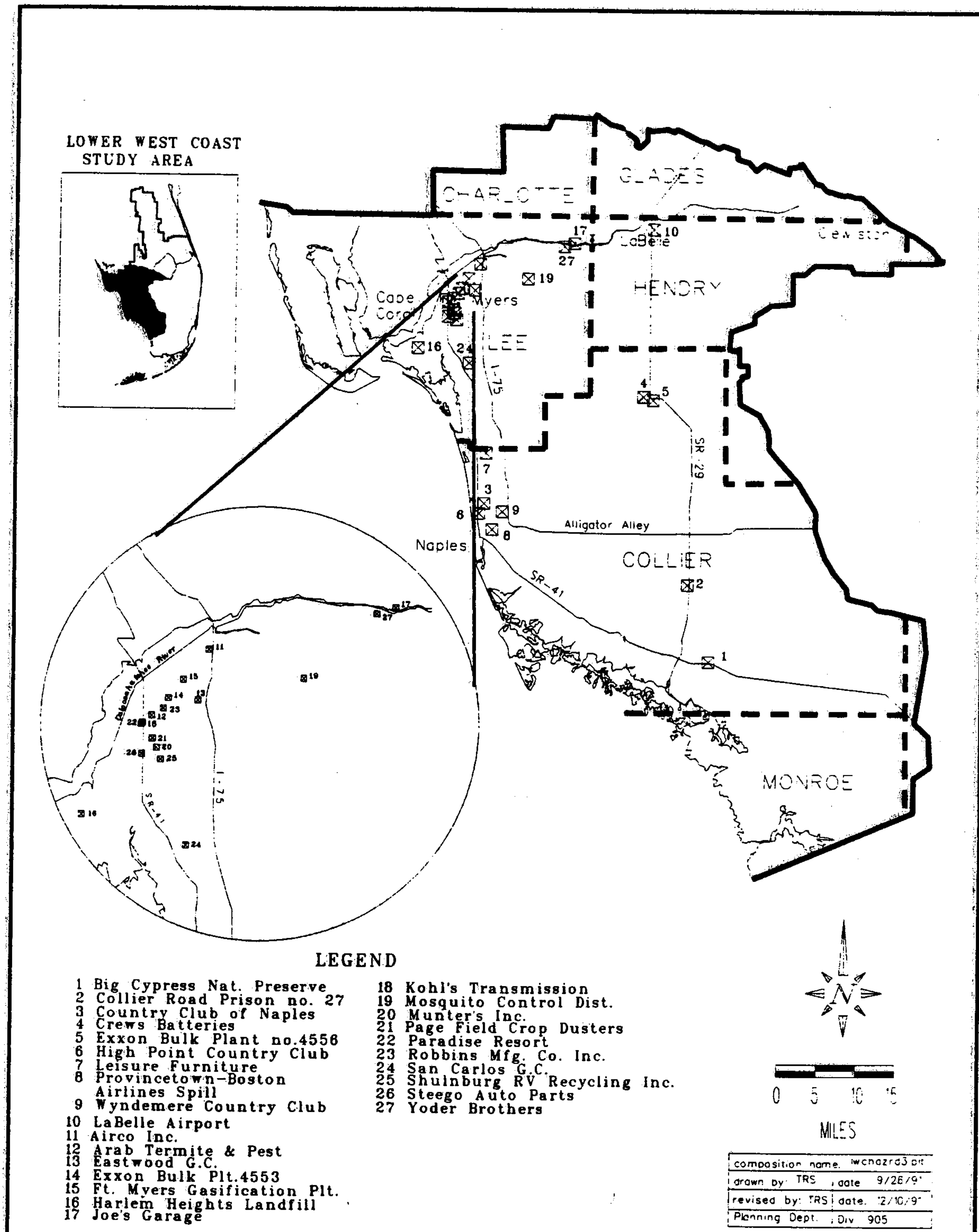

FIGURE H-51. Location of EPA Superfund Sites in the Lower West Coast Planning Area.

FDER Hazardous Waste Sites

The Resource Conservation and Recovery Act (RCRA) was enacted by Congress in 1976. Regulations developed by the U.S. EPA to implement the Act, are intended to provide cradle-to-grave management of hazardous waste. There are 18 FDER hazardous waste program sites identified in the LWC Planning Area (Letter dated January 17, 1991 from P.R. Edwards, Deputy Assistant Secretary, FDER South District, Fort Myers, FL). The locations of these sites are shown in Figure H-52.

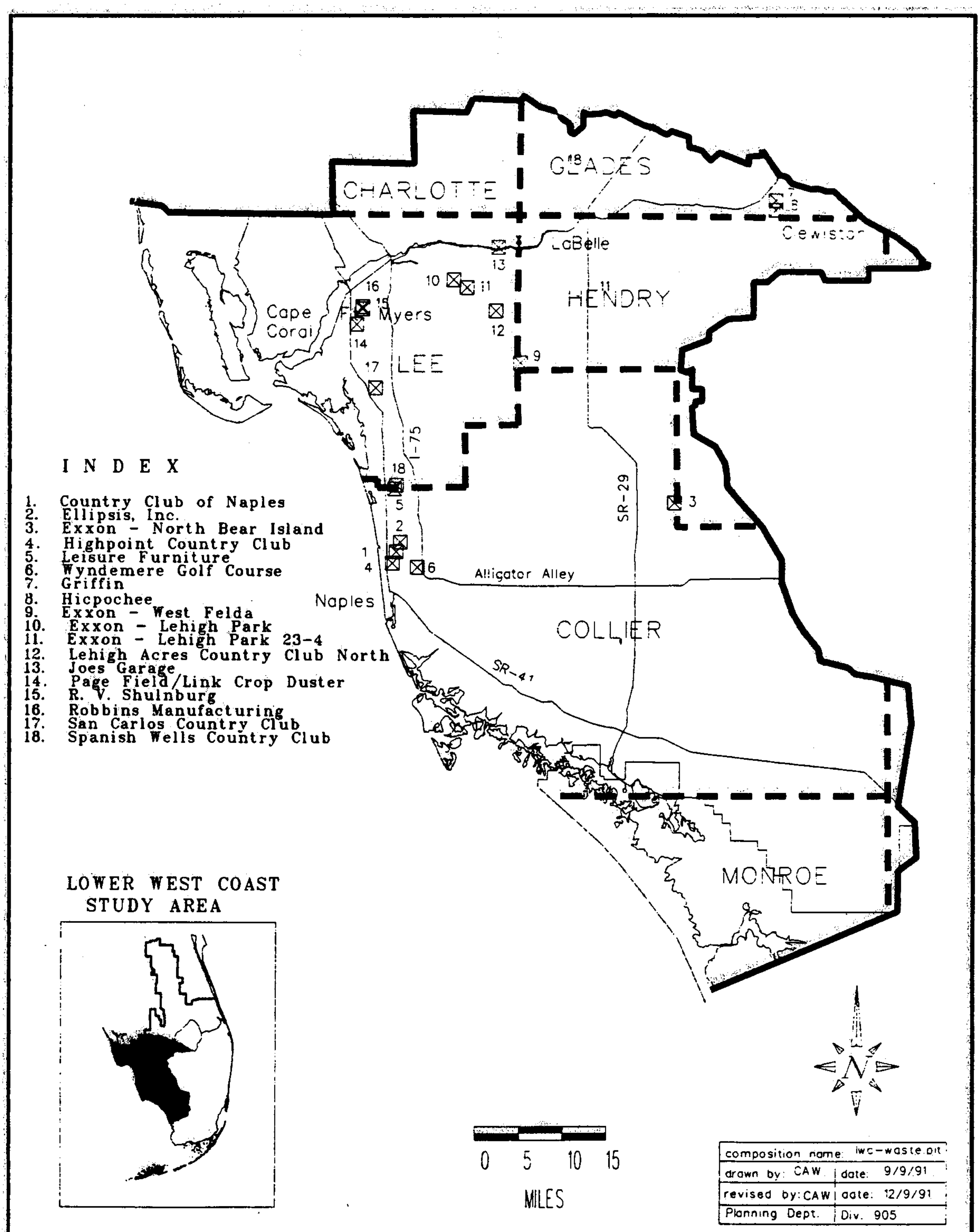

FIGURE H-52. **FDER Hazardous Waste Program Sites in the Lower West Coast Planning Area.**

WELLFIELD PROTECTION ORDINANCES

It is far more cost effective to utilize an unpolluted raw water source than one which will require add-on treatment processes or a higher level and more costly overall treatment method. The ability of local government to effectively regulate and control existing and potential ground water contamination is critical to protecting and optimizing the fresh ground water resource.

Wellfield protection ordinances are locally adopted ordinances that are intended to provide long-term protection of the ground water resources in areas surrounding potable water supply wells. Contamination of supply wells is prevented through managing land uses, regulating well construction and abandonment, and controlling the storage, handling, use and production of hazardous or toxic materials. Wellfield protection ordinances consist of several wellfield protection zones, which are delineated by determining ground water travel times within the area of the wellfield. The innermost zone, which has the shortest travel time, is afforded the most protection from potential pollution.

Lee and Collier counties are the only counties with wellfield protection ordinances in effect in the LWC Planning Area. Lee County adopted an ordinance in August 1989, and Collier County adopted its ordinance in October 1991. These wellfield protection zones are presented in figures H-53 and H-54.

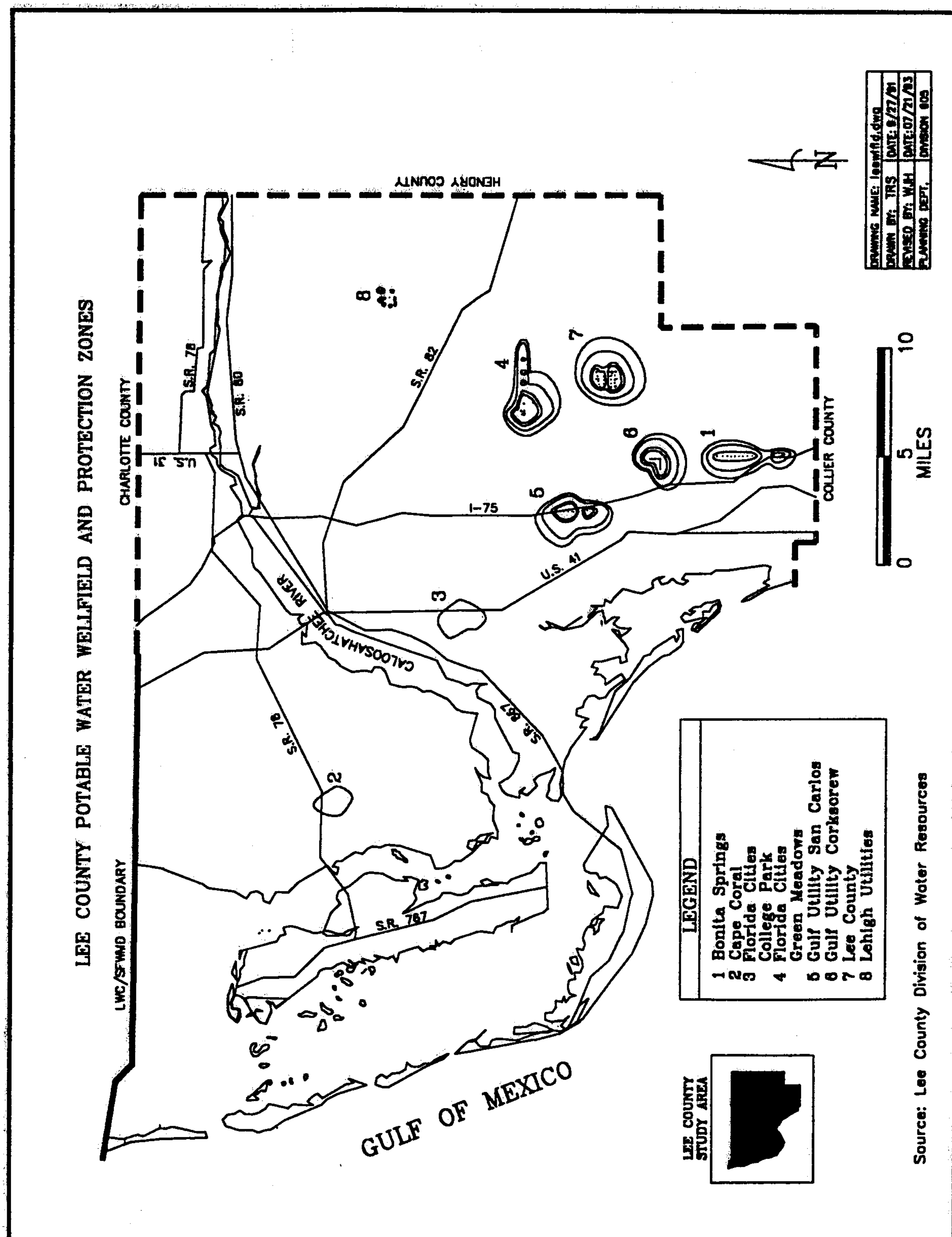

FIGURE H-53. Lee County Potable Water Wellfield and Protection Zones.

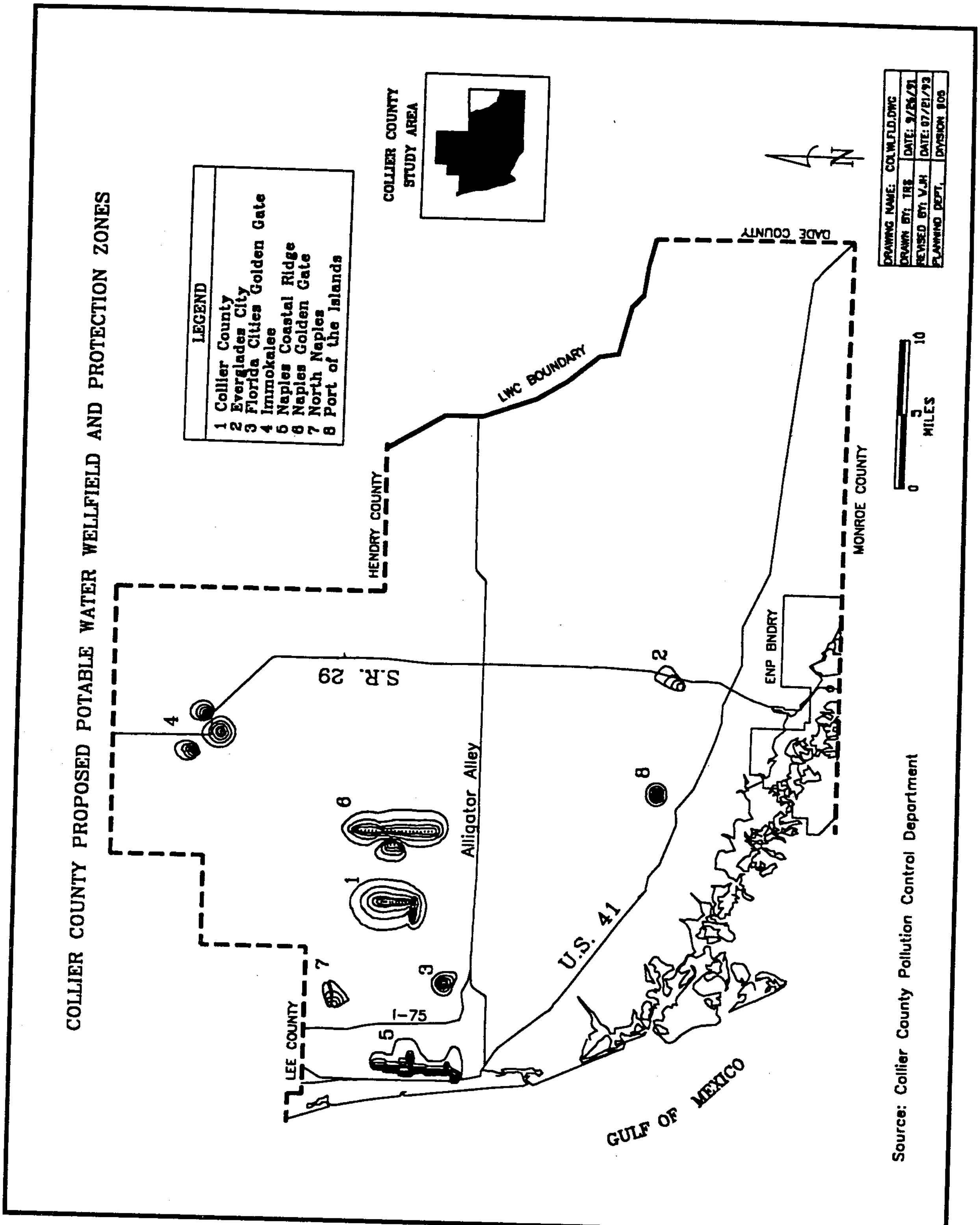

FIGURE H-54. Collier County Proposed Potable Water Wellfield and Protection Zones.

SALTWATER INTRUSION

Saltwater intrusion along the coast of the LWC Planning Area has been advanced by canal excavation and aquifer development for public water supplies and agriculture. In some channels, salinity control structures have been installed to limit saltwater encroachment by maintaining freshwater heads on the inland side. The greatest threat from saltwater intrusion lies where ground water and surface water gradients are lowest. Saltwater intrusion has been most evident in the lower Tamiami aquifer in the Naples Coastal Ridge and Bonita Springs/North Naples areas, and also in the water table aquifer in the area of Marco Island's public water supply withdrawals.

The SFWMD maintains a saltwater intrusion database called SALT that collects information on chloride, specific conductance, and water levels from the District's monitoring network. The monitoring network consists of data supplied by the public water supply utilities and USGS monitoring wells. Selected data acquired from this network, the USGS, and the District's DB-Hydro database were used to construct maps of average chloride concentrations in monitor wells in the water table, lower Tamiami, and mid-Hawthorn aquifers. Isochlor contour maps were generated by performing an inverse distance weighted (IDW) interpolation on the point data set using ARC/INFO GRID. The isochlor maps are intended to serve as an aid in visualizing the distribution of known values, rather than as an absolute indicator of saltwater intrusion. Figures H-55 through H-67 are maps containing well locations, average chloride concentrations and isochlors. A graph showing long-term increases in chloride concentrations in a lower Tamiami well, L-738 in the Bonita Springs area, is included as Figure H-68.

In addition to saltwater intrusion from coastal waters, overdevelopment of aquifers which overlie more saline aquifers increases the possibility of upconing and contamination from the poorer quality layers. This potential exists throughout the planning area. Although upconing of saline water is not considered to be true seawater intrusion, it is a significant threat because of its potential to degrade potable water supplies. Figure H-69 illustrates a long-term chloride increase in lower Hawthorn well L-2435, where chloride concentrations rose from 1,500 mg/L in late water year 1978 to a high of approximately 3,900 mg/L in early water year 1988. Recharge in this case, comes largely from the underlying Suwannee Aquifer, raising chloride and total dissolved solids concentrations in the lower Hawthorn. This example also illustrates the necessity of long term observations in evaluating aquifer impacts.

Cross contamination of shallow aquifers has also occurred from many of the Floridan aquifer wells in the planning area. Numerous artesian wells were drilled into the highly mineralized Floridan Aquifer System from the 1930s through the 1950s for agricultural water supply and oil exploration. Many of these wells were short-cased, meaning the casings extended to less than about 200 feet below land surface, which exposed the shallower zones to invasion by the more saline Floridan water. Additionally, steel casings may have corroded, allowing inter-aquifer exchange through the casings. Often, if a well was abandoned, it was either plugged improperly, or simply left open, free-flowing on the land surface, and recharging the surficial aquifer with saline water. The result is the existence of localized sites throughout the shallow aquifers containing anomalously high concentrations of dissolved minerals. This is evident in the water quality data and associated isochlor maps. The actual lateral influence of such impacts, however, is localized and may be exaggerated by the contour lines surrounding these areas.

In 1981 the Florida Legislature passed the Water Quality Assurance Act which required the water management districts to plug abandoned FAS wells. Under this program, many known wells in the LWC Planning Area were plugged. The federal government is currently offering a well abandonment program through the Soil Conservation Service for wells on specific agricultural lands.

Another source of localized pockets of mineralized water is connate water, theorized to be ancient seawater remaining from periods of inundation, entrapped within the aquifer, and relatively unexposed to freshwater flushing.

The effects of seawater intrusion, upconing, aquifer cross contamination, and connate water can create a complex and somewhat unpredictable scenario of local ground water quality. Monitor wells provide a great deal of information where they exist, but there are limits as to how many wells can be installed and monitored. Where more detailed information is required, additional methods may be needed to monitor the saltwater interface. The District recently participated in a cooperative study in Broward County which utilized a surface geophysical method for delineating saltwater intrusion. Geophysical surveys can provide extremely useful information about the extent of saltwater intrusion at relatively low cost (Benson and Yuhr, 1993).

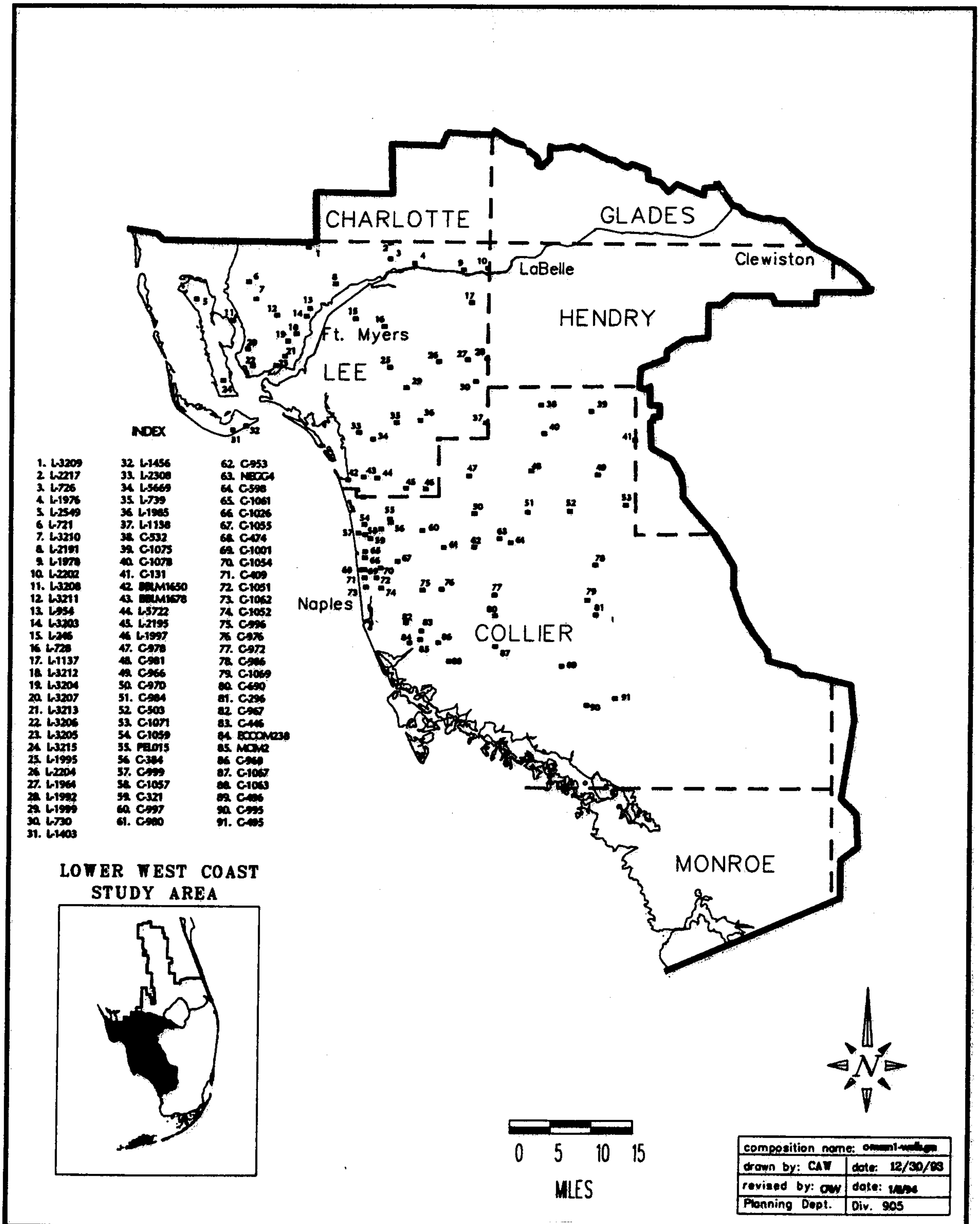

FIGURE H-55. Selected Monitor Wells for the Water Table Aquifer.

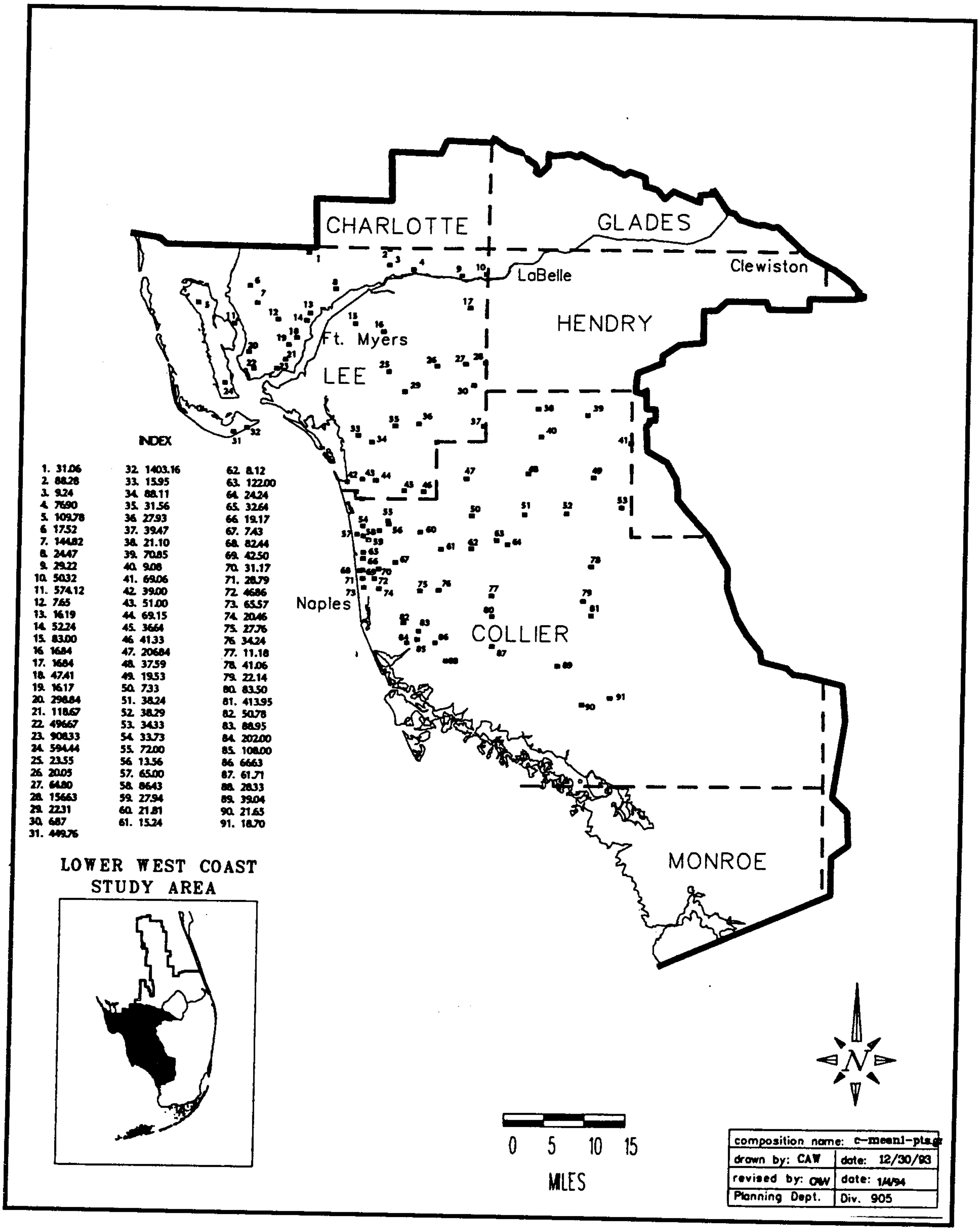

FIGURE H-56. Average Chloide Values for Selected Monitor Wells for the Water Table Aquifer (mg/L).

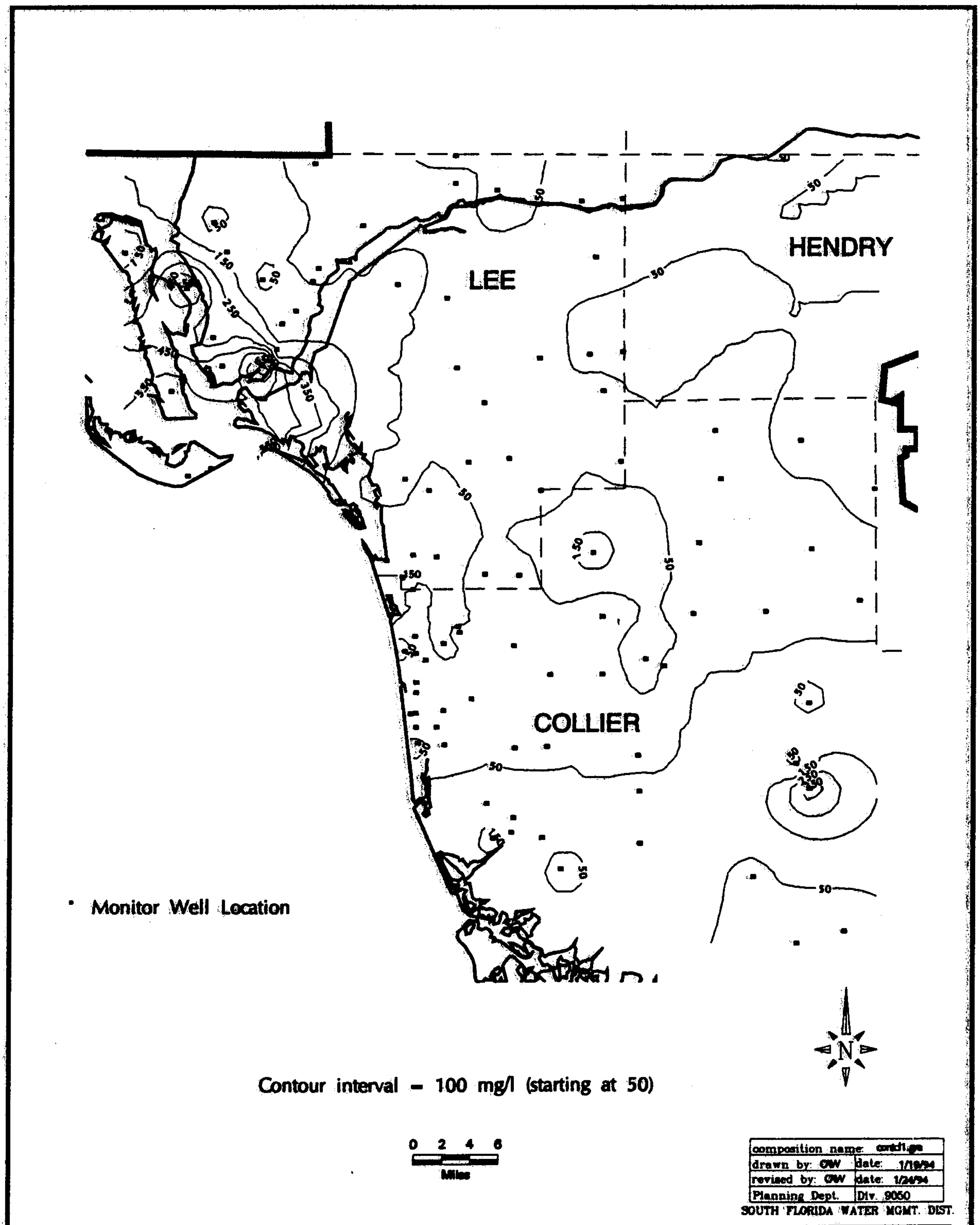

FIGURE H-57. Isochlor Map of the Water Table Aquifer (mg/L).

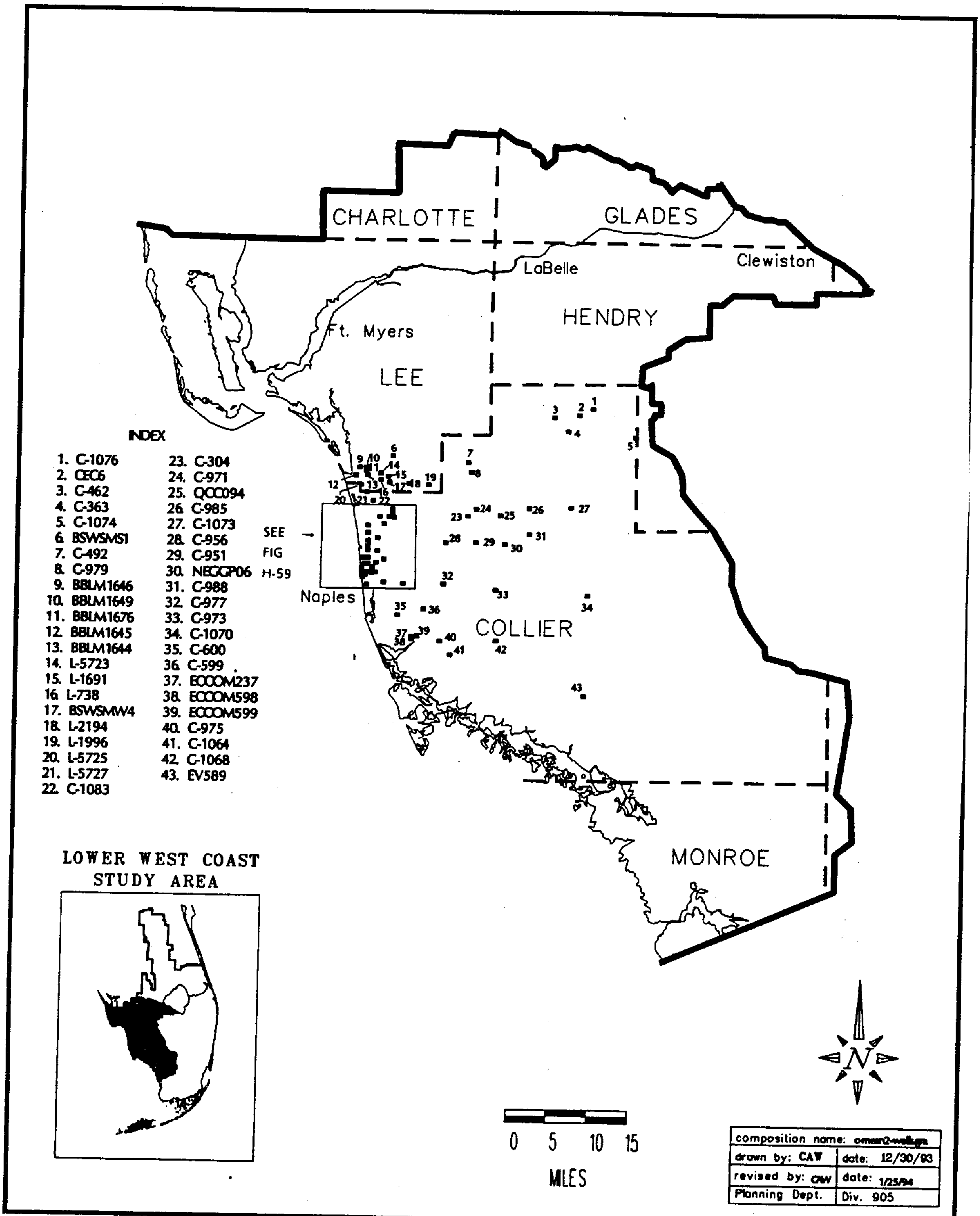

FIGURE H-58. Selected Monitor Wells for the Lower Tamiami Aquifer.

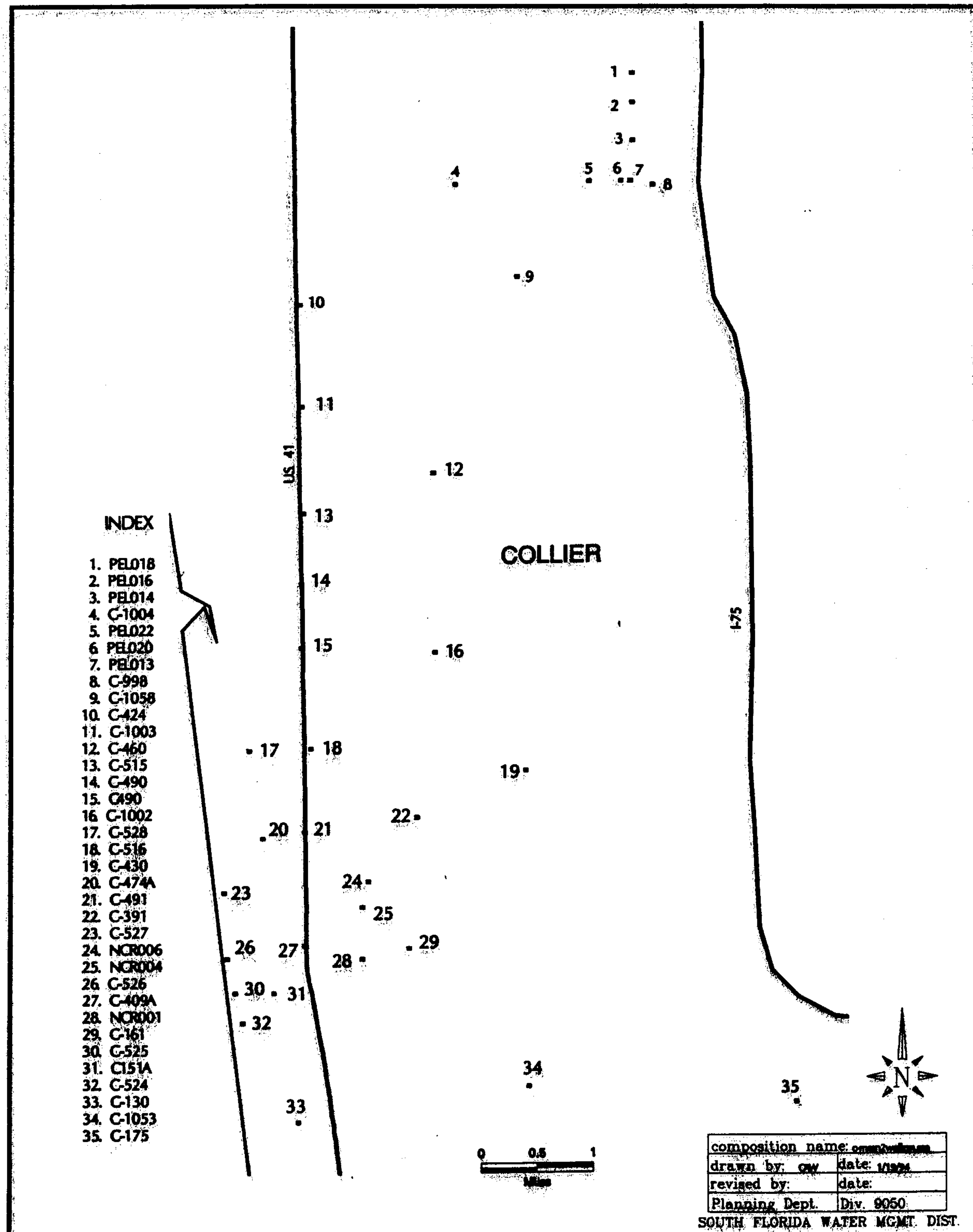

FIGURE H-59. Selected Monitor Wells for the Lower Tamiami Aquifer in the Naples Coastal Ridge Area.

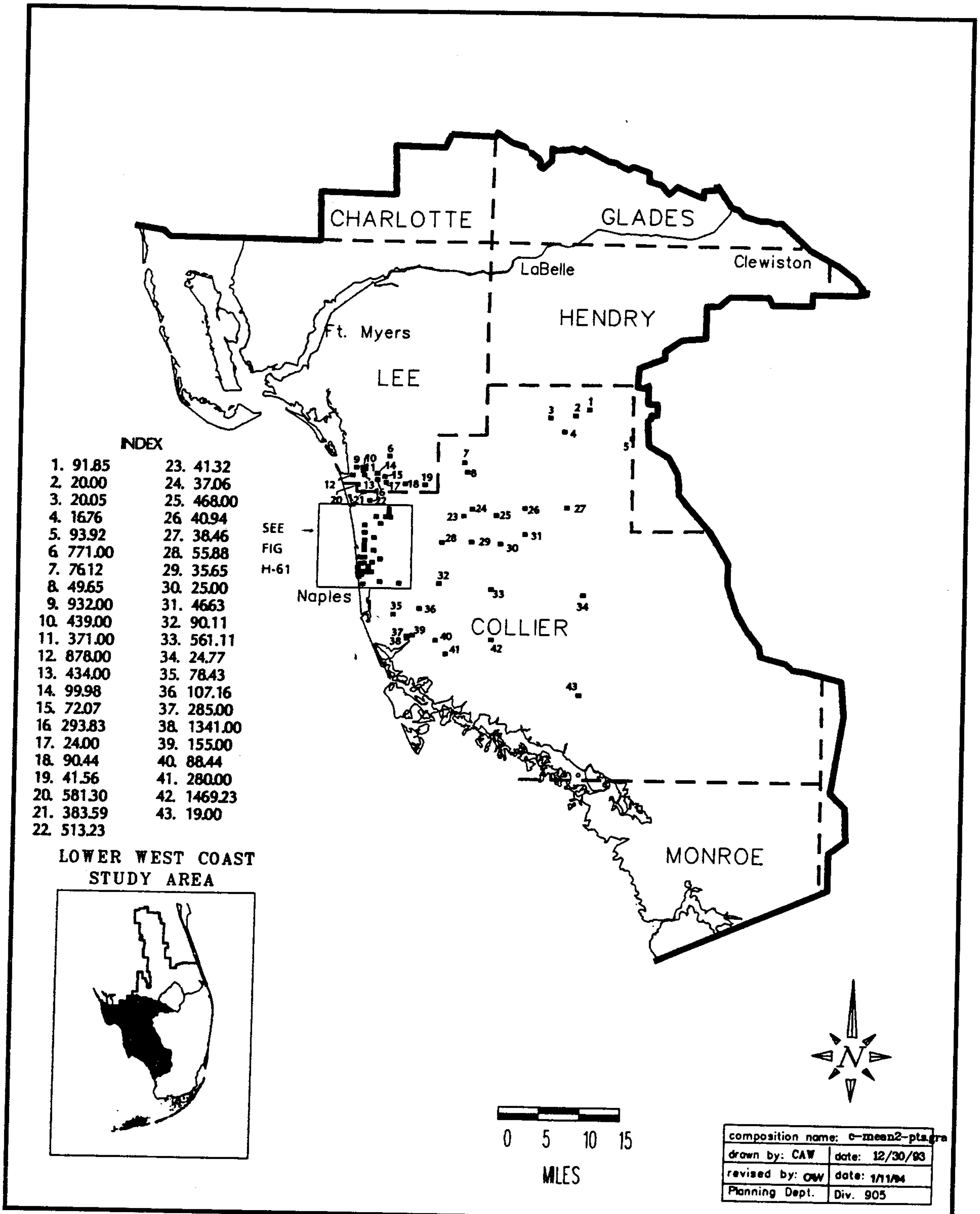

FIGURE H-60. Average Chloride Values for Selected Monitor Wells for the Lower Tamiami Aquifer (mg/L).

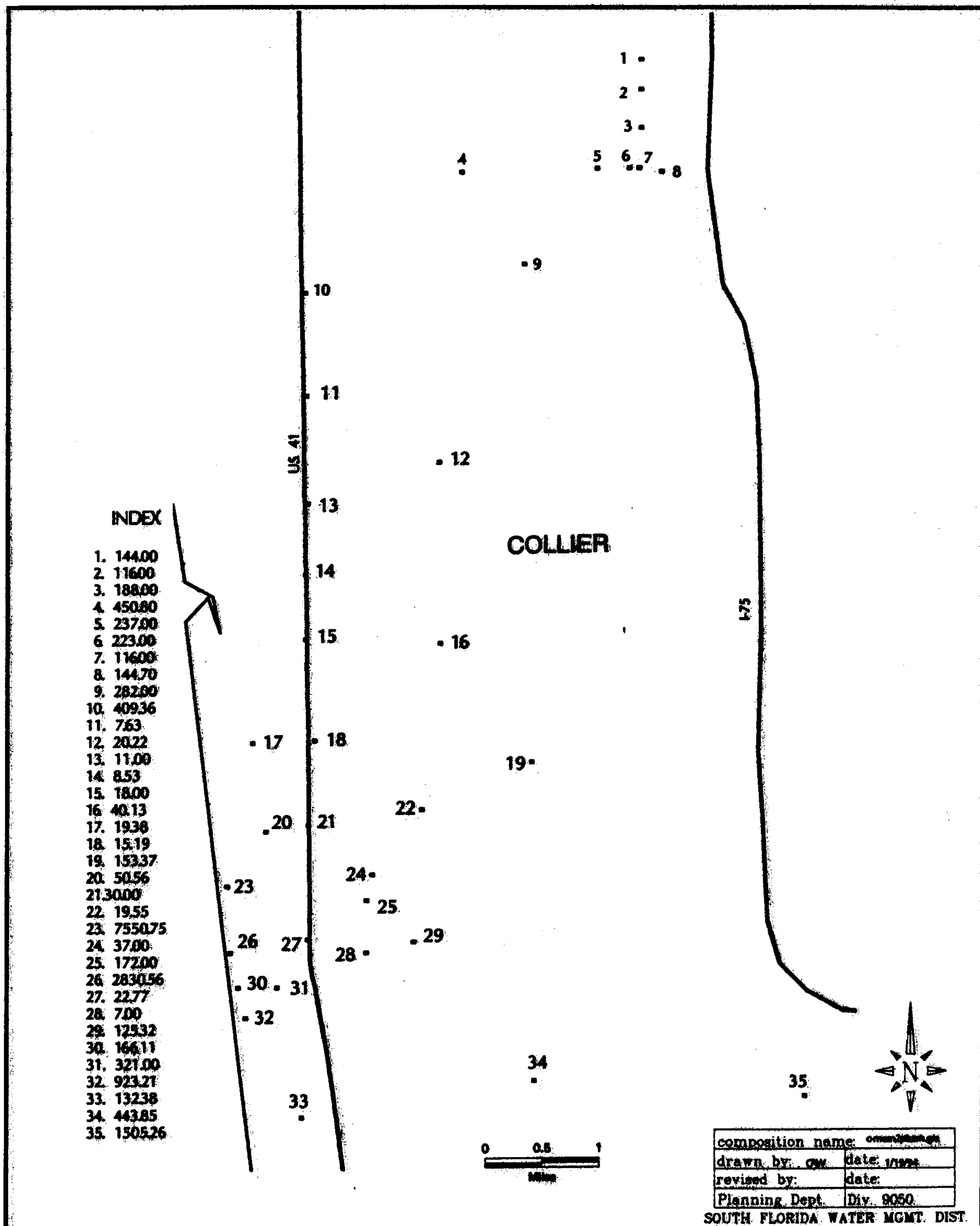

FIGURE H-61. Average Chloride Values for Selected Monitor Wells for the Lower Tamiami Aquifer in the Naples Coastal Ridge Area (mg/L).

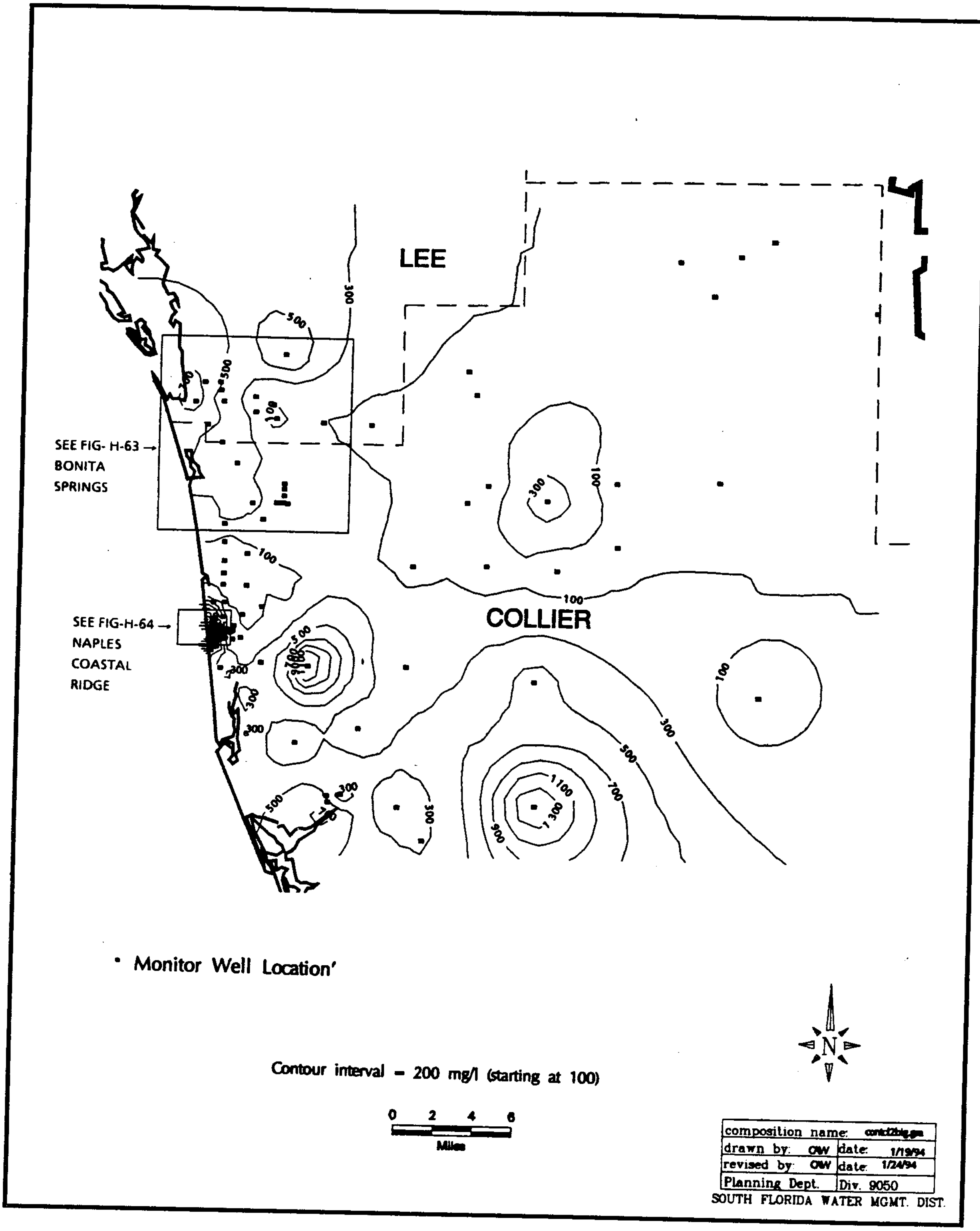

FIGURE H-62. Isochlor map of the Lower Tamiami Aquifer (mg/L).

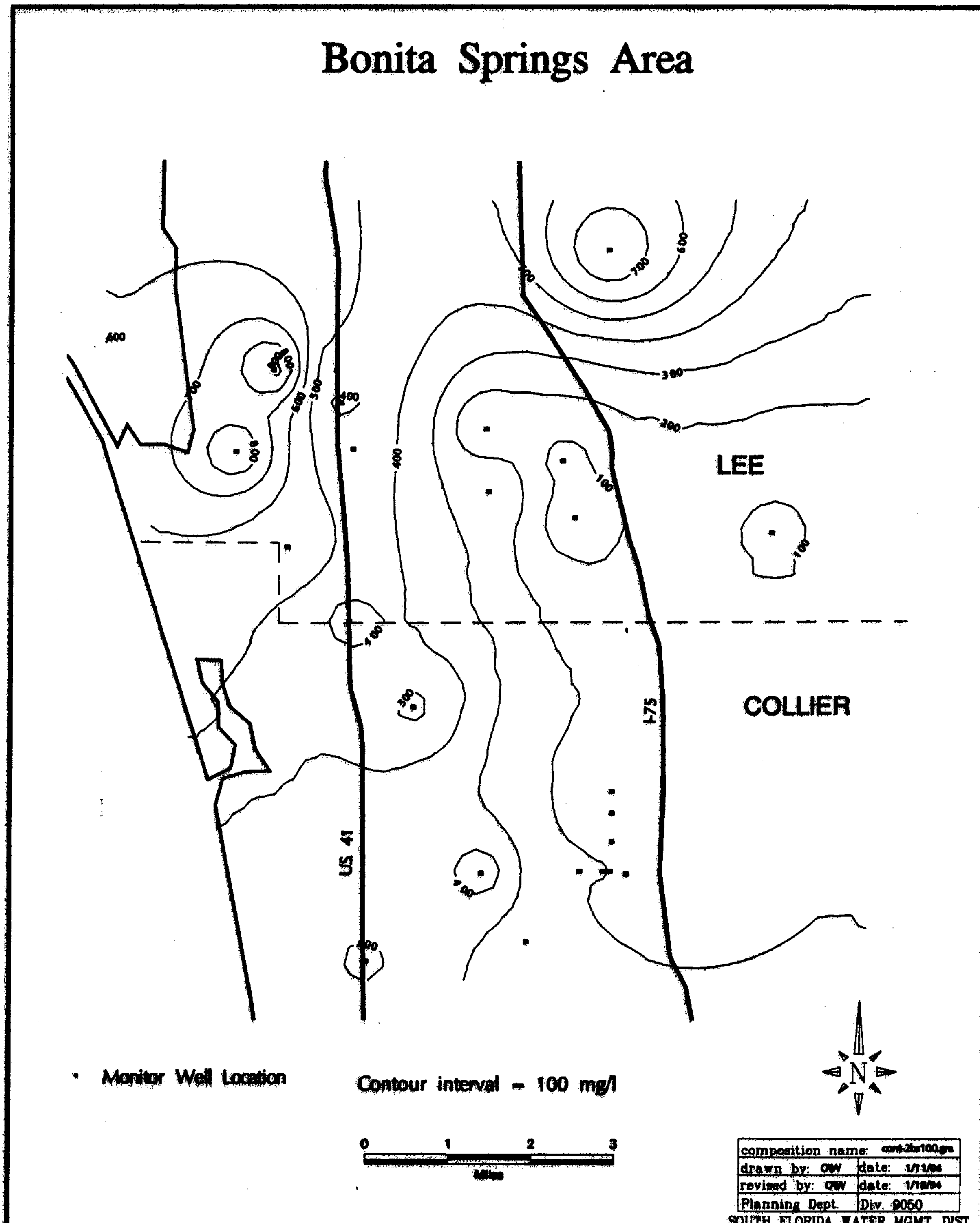

FIGURE H-63. Isochlor map of the Lower Tamiami Aquifer for the Bonita Springs/North Naples Area (mg/L).

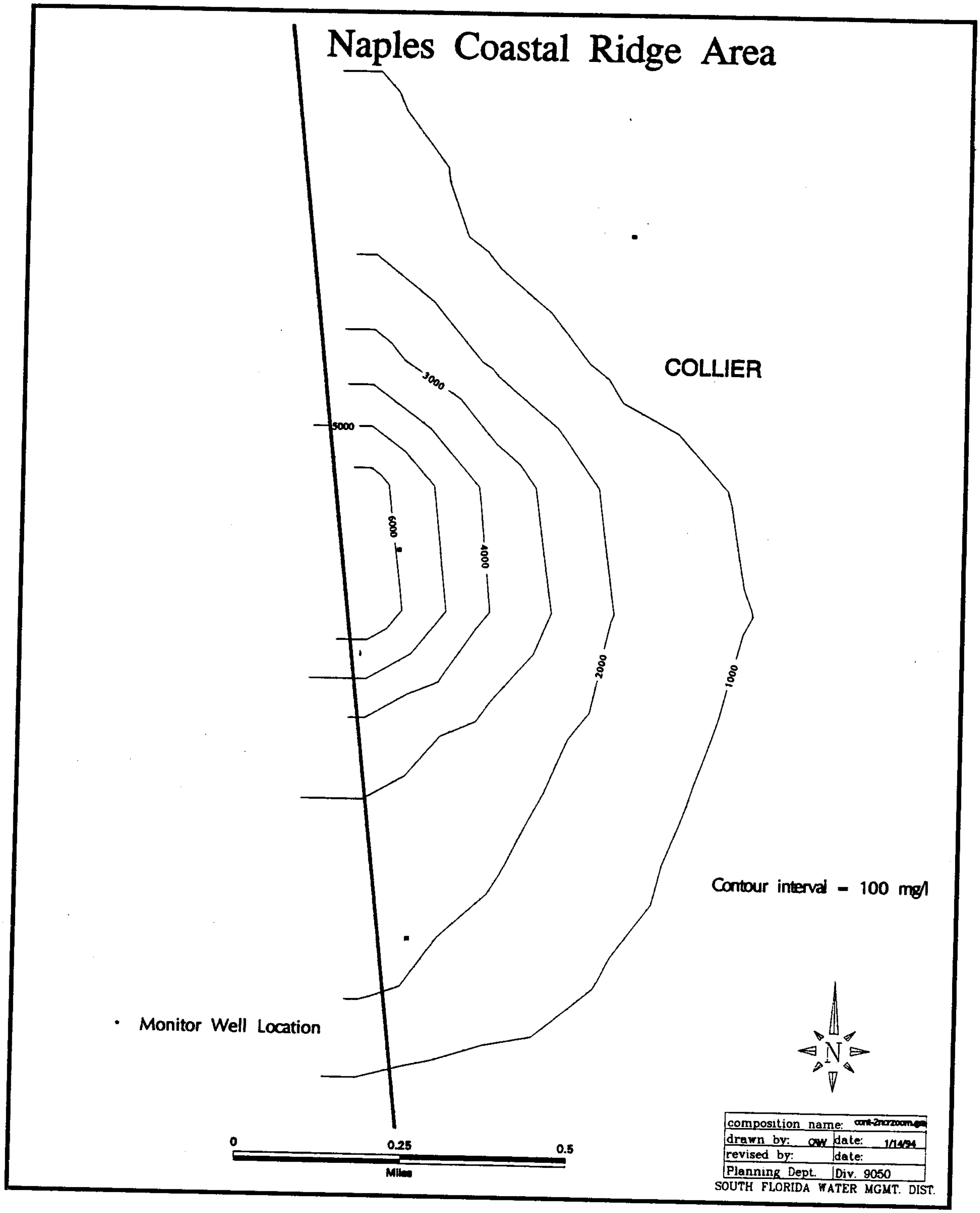

FIGURE H-64. Isochlor map of the Lower Tamiami Aquifer for the Naples Coastal Ridge Area (mg/L).

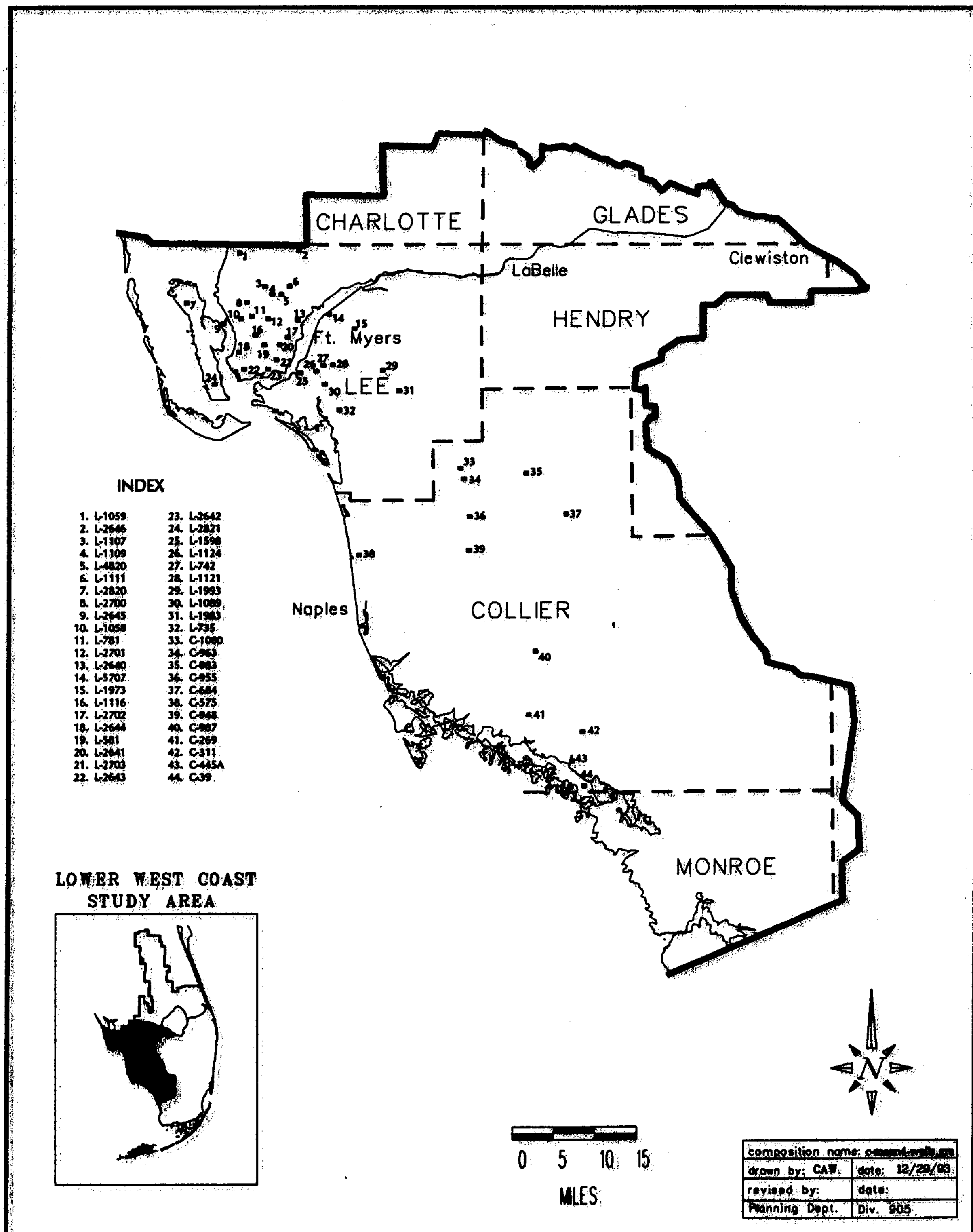

FIGURE H-65. Selected Monitor Wells for the Mid-Hawthorn Aquifer.

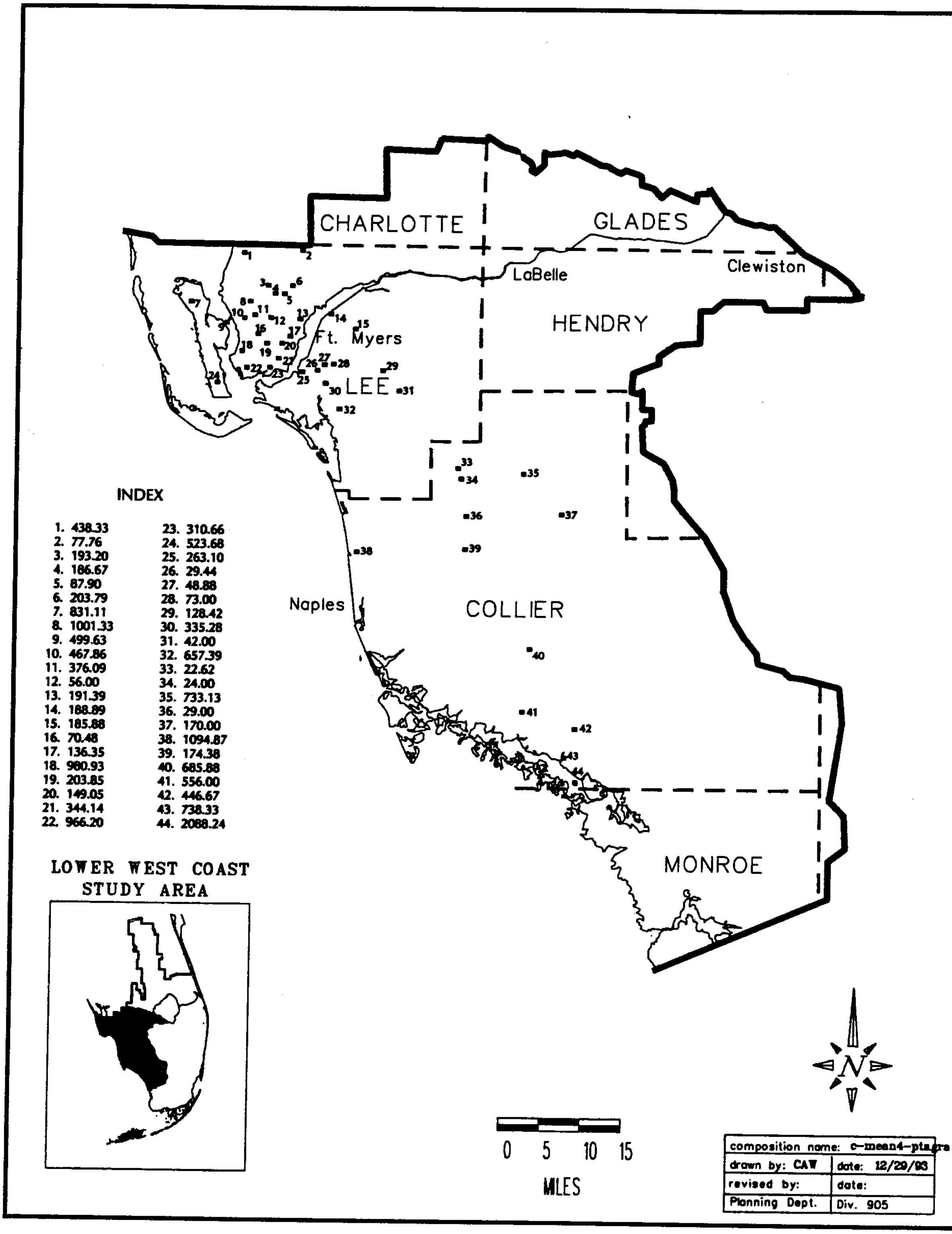

FIGURE H-66. Average Chloride Values for Selected Monitor Wells for the Mid-Hawthorn Aquifer (mg/L).

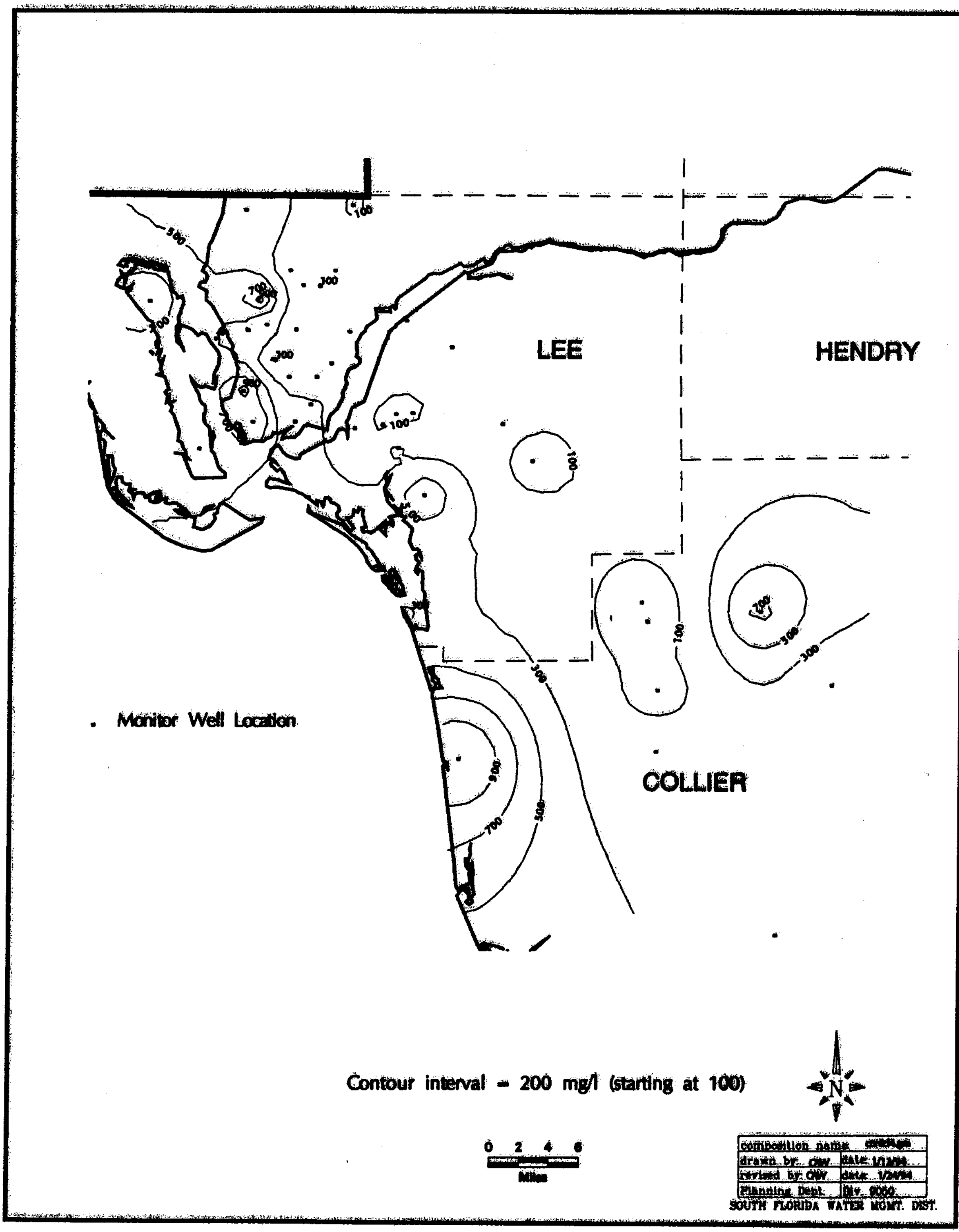

FIGURE H-67. Isochlor Map of the Mid-Hawthorn Aquifer (mg/L).

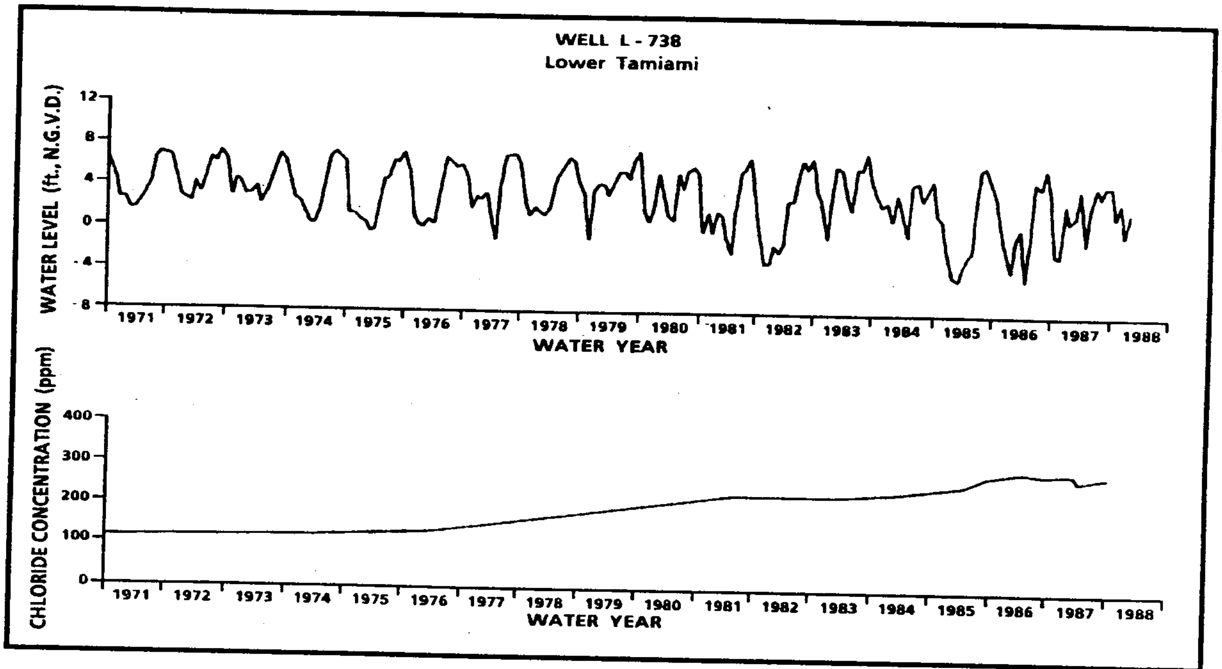

FIGURE H-69. Water Level/Chloride Concentration Comparison in Lower Tamiami Well L-738 (Bonita Springs). From: USGS. In: JMM, 1988.

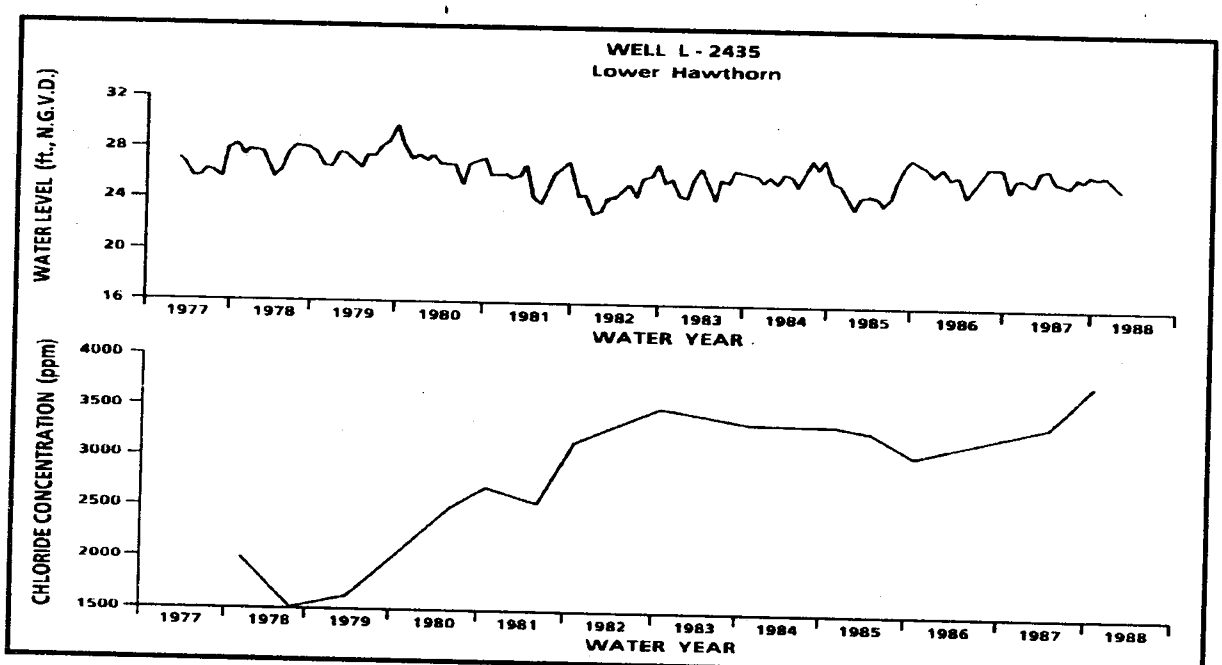

FIGURE H-70. Water Level/Chloride Concentration Comparison in Lower Hawthorn Well L-2435 (North Fort Myers). From: USGS. In: JMM, 1988.

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